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SEDIMENTOLOGY, PETROLOGY, AND GAS POTENTIAL OF THE BRALLIER FORMATION - UPPER DEVONIAN TURBIDITE FACIES OF THE CENTRAL AND SOUTHERN APPALACHIANS

By
Paul D. Lundegard
Neil D. Samuels
Wayne A. Pryor

March 1980

UNITED STATES DEPARTMENT OF ENERGY
Morgantown Energy Technology Center
Morgantown, West Virginia

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DOE METC 52015
Publicly Releasable
Reviewed by:
Barry Steele
1-28-04

DOE/METC/5201-5
Distribution Category UC-92

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Under Contract No. DE-AC21-76MC05201

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SEDIMENTOLOGY, PETROLOGY, AND GAS POTENTIAL OF THE BRALLIER FORMATION - UPPER DEVONIAN TURBIDITE FACIES OF THE CENTRAL AND SOUTHERN APPALACHIANS

By

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ABSTRACT

The Upper Devonian Brallier Formation of the central and southern Appalachian basin is a regressive sequence of siltstone turbidites interbedded with mudstones, claystones, and shales. It reaches 1000 meters in thickness and overlies basinal mudrocks and underlies deltaic sandstones and mudrocks. Facies and paleocurrent analyses indicate differences between the depositional system of the Brallier Formation and those of modern submarine fans and ancient Alpine flysch-type sequences. The Brallier system is of finer grain size and lower flow intensity. In addition, the stratigraphic transition from turbidites to deltaic sediments is gradual and differs in its facies succession from the deposits of the proximal parts of modern submarine fans. Such features as massive and pebbly sandstones, conglomerates, debris flows, and massive slump structures are absent from this transition.

Paleocurrents are uniformly to the west at right angles to basin isopach, which is atypical of ancient turbidite systems. This suggests that turbidity currents had multiple point sources. The petrography and paleocurrents of the Brallier Formation indicate an eastern source of sedimentary and low-grade metasedimentary rocks with modern relief and rainfall.

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The depositional system of the Brallier Formation is interpreted as a series of small ephemeral turbidite lobes of low flow intensity which coalesced in time to produce a laterally extensive wedge. The lobes were fed by deltas rather than submarine canyons or upper fan channel systems.

This study shows that the present-day turbidite facies model, based mainly on modern submarine fans and ancient Alpine flysch-type sequences, does not adequately describe prodeltaic turbidite systems such as the Brallier Formation.

Thickly bedded siltstone bundles are common features of the Brallier Formation and are probably its best gas reservoir facies, especially when fracture porosity is well developed.

Key Ideas: *turbidites, sedimentology, paleocurrents, gas reservoir facies, Upper Devonian of the Appalachian basin.*

INTRODUCTION

The Brallier Formation (Upper Devonian) is a thick (up to 3400 feet) regressive sequence of distal to proximal siltstone turbidites, interbedded with mudstone, claystone, and shale. It outcrops primarily in the Valley and Ridge Province, from south-central Pennsylvania to southwestern Virginia, with a few exposures in the Allegheny Plateau Province of West Virginia (Fig. 1).

In the Valley and Ridge Province, structural strike trends north-northeast and strata outcrop in a series of elongate anticlines and synclines. In the northern part of the study area, folds are the dominant structure, but thrust faults become more common to the south. Bedding generally dips less than 50 degrees and is overturned locally in the vicinity of thrust faults. The few outcrops of the Brallier Formation in the Allegheny Plateau occur on the flanks of broad, gentle folds.

The present study is the first detailed regional sedimentologic analaysis of the Upper Devonian slope facies in the central and southern Appalachian basin. There have been few studies of the Brallier Formation. Butts (1918) named the unit in Bedford County, Pennsylvania. Since then Walker (1967, 1971) and Frakes (1967) have studied the Trimmers Rock Formation (a name now abandoned), which is partially equivalent to the Brallier Formation. Walker (1967) studied vertical variations in turbidite sedimentary structures at Woodmont and Oldtown, Maryland, and proximal-distal relationships in turbidites in Pennsylvania. Frakes (1967) also interpreted the nature of the Late Devonian

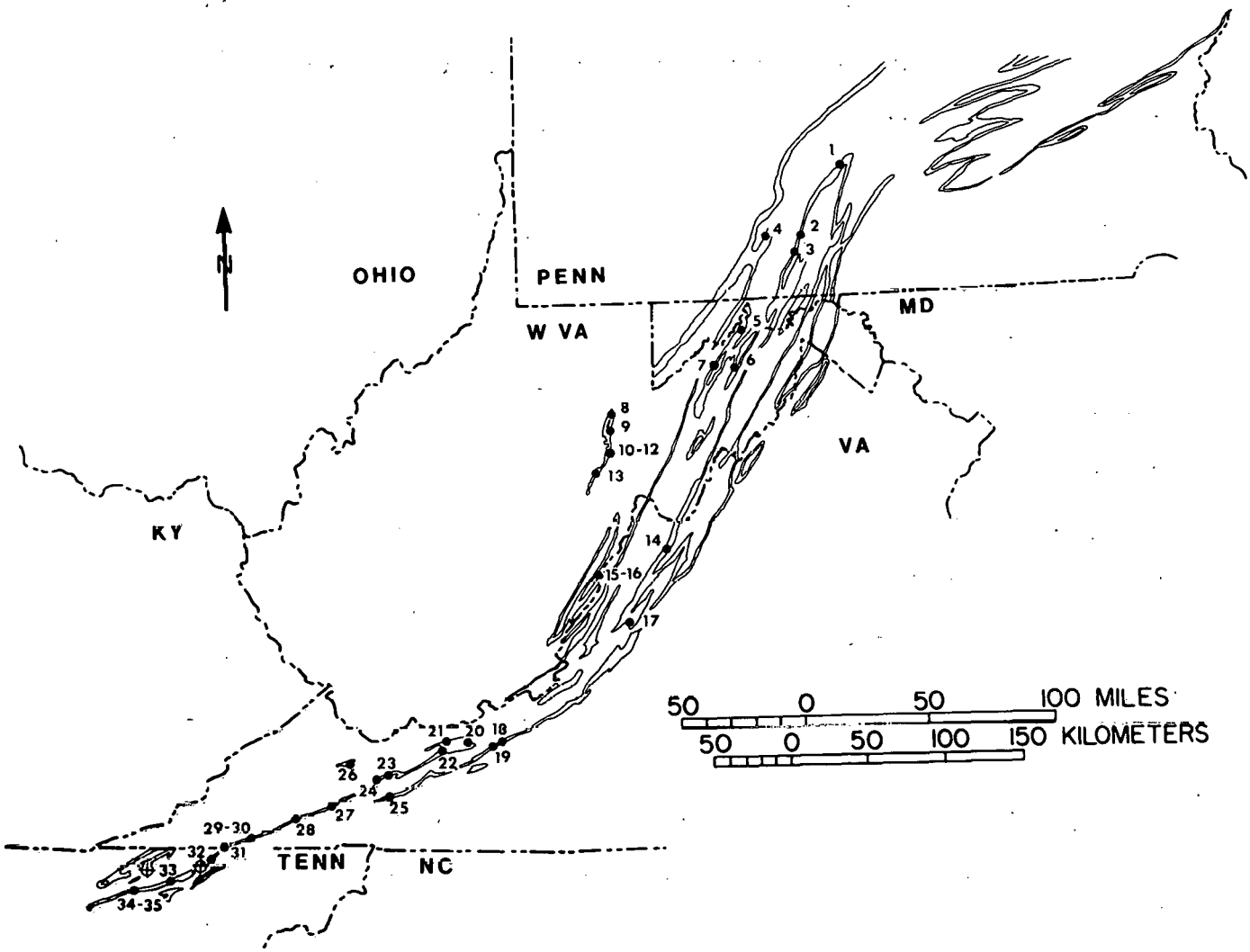


Figure 1. Map of study area showing outcrop of Brallier Formation and measured sections. Sections numbers are keyed to description in Appendix. The location of the two eastern Tennessee cores which were studied are also shown: eastern core is TDG-DOE-4; western core is TDG-DOE-3. Both locations are shown by symbol

paleoslope in Pennsylvania based on his stratigraphic and sedimentologic study of the Trimmers Rock Formation. McIver (1970) discussed the sedimentation of Upper Devonian turbidites in the central Appalachians and compared and contrasted them with the Martinsburg turbidites (Ordovician).

There have been no modern sedimentologic studies of the Brallier Formation in either Virginia or West Virginia. Butts (1940) briefly described the Brallier in Virginia, as Woodward (1943) did in West Virginia; Woodward also compiled an isopach map. Dennison (1970, Fig. 3) included the Brallier in a cross section of Devonian strata along the Allegheny Front in West Virginia and Maryland. Avary and Dennison (1978) mapped the Back Creek Siltstone, an informal member of the Brallier Formation, in parts of West Virginia and Virginia. In the Greendale syncline belt of eastern Tennessee, Dennison and Boucot (1974, p. 80) identified strata of "Brallier lithology" in the Chattanooga Shale.

We examined the Brallier Formation throughout its outcrop in Pennsylvania, Maryland, West Virginia, and Virginia (Fig. 1). In addition, although the Brallier Formation has not been formally recognized in eastern Tennessee, we studied the gray silty shale unit of the Chattanooga Shale with which it is probably correlative.

The Brallier Formation occurs within a conformable sequence and overlies the basinal, dark colored mudrocks of the Harrell Shale, Millboro Shale, or Mahantango Formation (Fig. 2). Above it are the "shelf" sandstones and mudrocks of the Foreknobs and "Chemung" Forma-

tions (Fig. 2). In Pennsylvania and northern West Virginia, the Scherr Formation lies between the Brallier and Foreknobs Formations. The Scherr is slightly coarser grained, but otherwise similar to the Brallier and is probably another facies of this formation (Dennison, 1970, Fig. 3).

The Brallier Formation occurs everywhere in a regressive basin-slope-shelf facies tract (Fig. 3), although its bounding stratigraphic units vary in both nature and nomenclature. It includes deposits of both the base-of-slope and slope environments.

The purpose of this study is twofold. First, we wish to assess the potential of the Brallier Formation as a gas reservoir. Analogous Upper Devonian facies are currently yielding gas in the subsurface of northern West Virginia. We believe that an outcrop study of the Brallier Formation will aid in predicting gas production elsewhere in the Appalachian basin and certainly enhances our general understanding of the Upper Devonian in the Appalachian basin. Questions of interest include: which facies of the Brallier Formation are the best gas reservoirs, what are their salient features, and where will they be found in the subsurface? Our second goal is to reconstruct sedimentation conditions on the Upper Devonian paleoslope of the Appalachian basin and to develop a depositional model for this environment based on our analysis of the paleocurrents and lithofacies of the Brallier Formation.

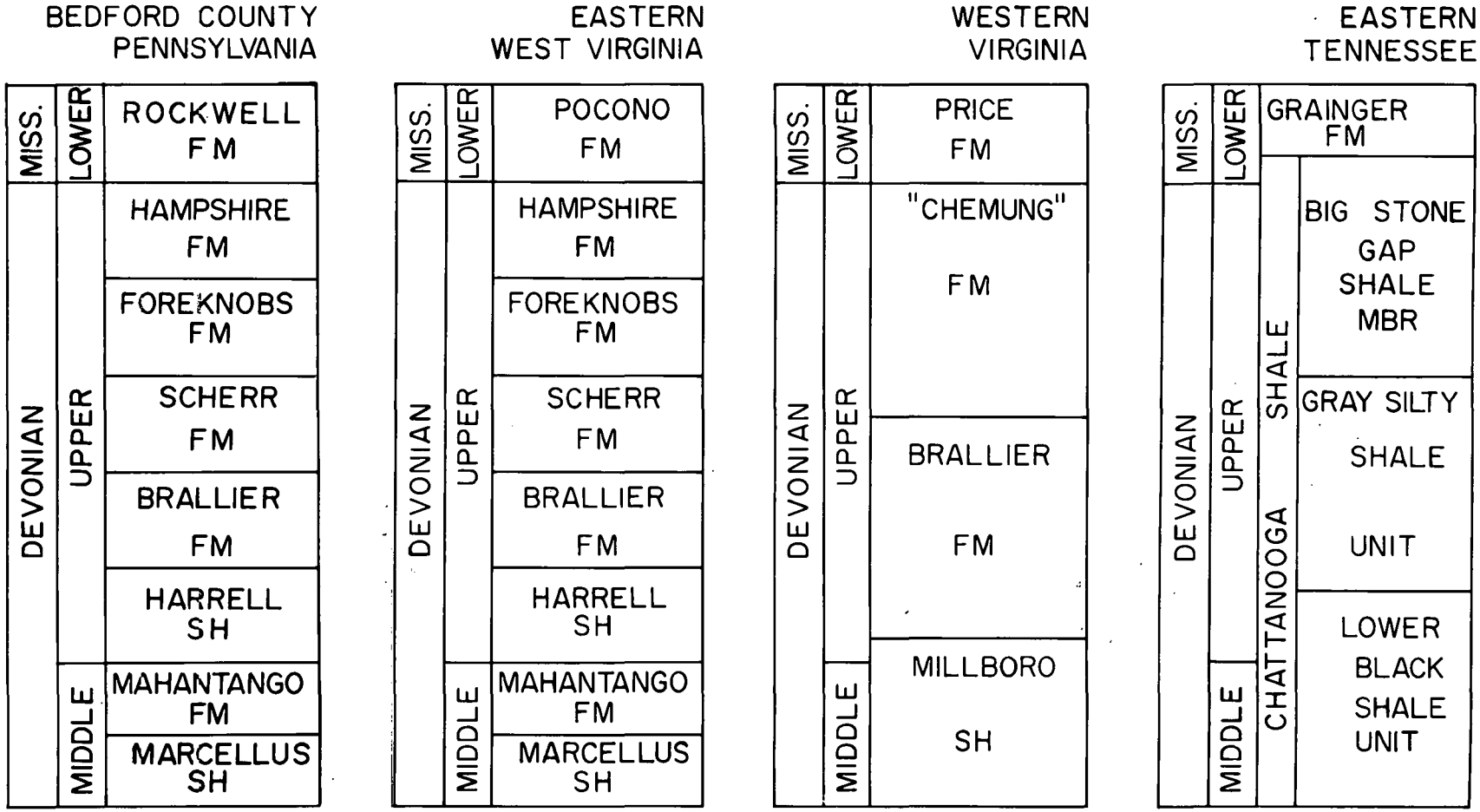


Figure 2 Stratigraphic nomenclature in the different regions of the study area. Sources: Bedford County, Pennsylvania -- Tom Berg, Pennsylvania Geological Survey, Field Mapping Division (personal communication); Eastern West Virginia -- Dennison (1970); West Virginia - Milici and others (1963); Eastern Tennessee -- Oliver et al. (1969).

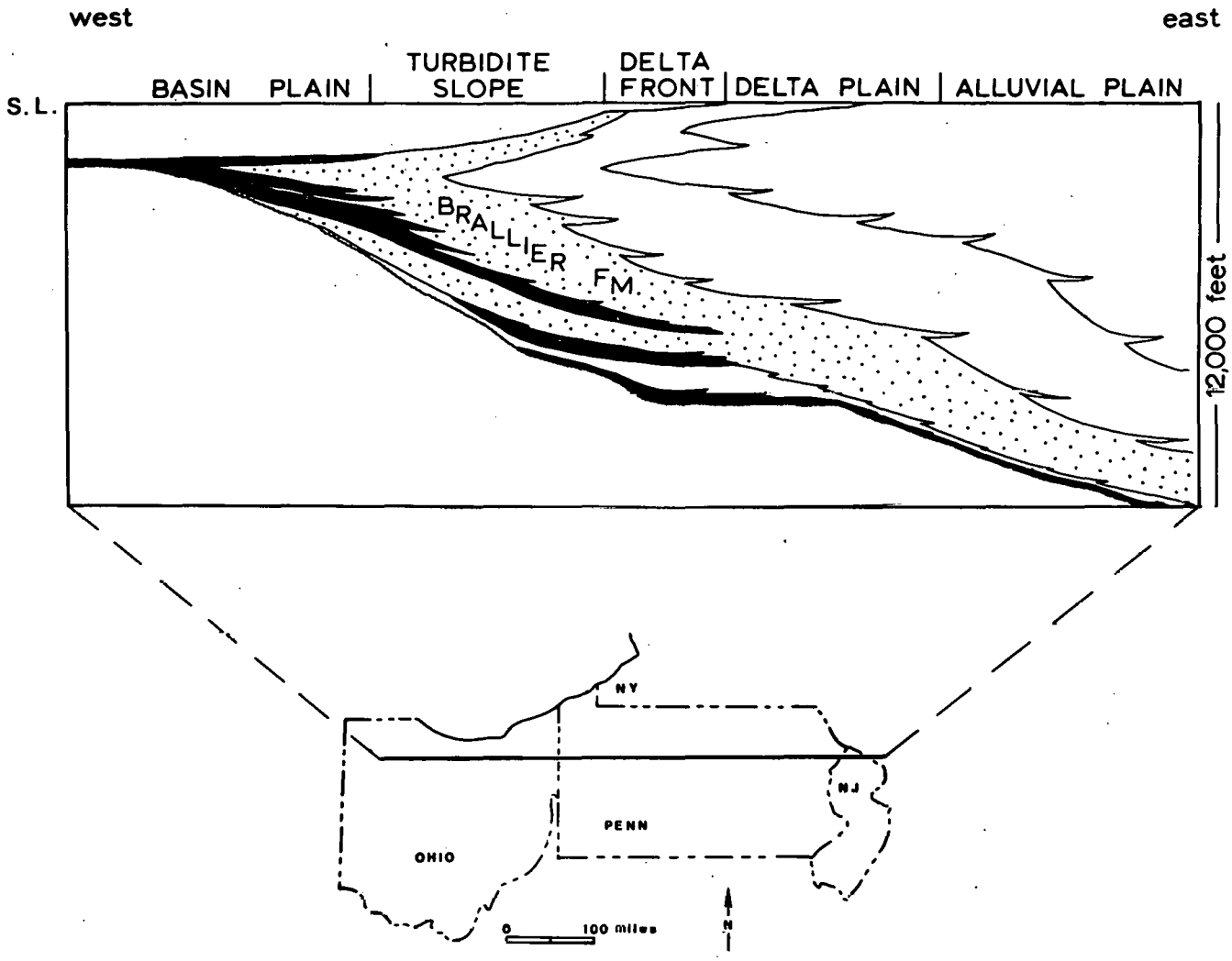


FIGURE 3 Schematic cross section of Upper Devonian rocks showing position of Brallier Formation in basin-slope-shelf facies tract. Black areas represent black shale units. Data from diverse sources.

PETROLOGY

A total of 101 outcrop samples of the Brallier Formation and related rocks, including 62 siltstones and 39 mudrocks were collected for thin section analysis. Subsamples were selected for clay mineral and bulk rock analysis as well as for determination of organic carbon.

Thin Section Analysis

Thin sections were cut perpendicular to the bedding planes of the samples and 200 points were counted in thin-section areas of approximately one square inch. The results of these analyses are summarized in Tables 1 and 2. In analyzing siltstones the following components were recognized: quartz, feldspars, rock fragments, micas, matrix, cement and heavy minerals. According to the classification scheme of McBride (1963), the majority of the Brallier siltstones are sublitharenites (Fig. 4).

Two varieties of quartz were recognized, monocrystalline and polycrystalline. These averaged 56 percent and 3.5 percent, respectively. Maximum grain size ranges from 70 to 230 microns and averages 155 microns which is in the fine sand range. Grains are typically angular to subangular in shape and show at least slightly undulose extinction. Elongate grains or "chips" are very common, and generally show a preferred orientation parallel to bedding (Fig. 5B). Contacts between quartz grains or between quartz and feldspar grains are commonly long or concave-convex, giving the rock an annealed appearance. Sutured contacts and isolated grains are rare.

TABLE 1

PETROGRAPHIC SUMMARY OF BRALLIER FORMATION SILTSTONES (N=62)

	QUARTZ		FELDSPAR			MICA			ROCK FRAGMENTS				MATRIX	CEMENT		OTHER
	Monocrystalline	Polycrystalline	Plagioclase	Orthoclase	Microcline	Muscovite	Biotite	Chlorite	Metamorphic	Quartz-Polymineralic	Sedimentary	Chert		Silica	Carbonate	
Mean	52.2	5.6	0.7	0.2	T	3.0	0.7	1.3	8.5	1.3	1.4	0.6	15.5	0.7	3.8	4.5
Min.	27.0	T	-	-	-	T	T	T	0.5	-	-	-	2.5	-	-	-
Max.	83.5	19.0	5.5	2.3	0.5	10.0	6.5	5.0	24.0	4.5	8.0	4.5	34.5	4.0	4.0	13.0

T = trace

TABLE 2

PETROGRAPHIC SUMMARY OF BRALLIER FORMATION

MUDSTONES, CLAYSTONES AND SHALES (N=39)

	QUARTZ		FELDSPAR	ROCK FRAGMENTS	ORGANICS	CLAY MATRIX	MICA	OTHER	MAXIMUM GRAIN SIZE (microns)	
	Monocrystalline	Polycrystalline							Disseminated	In Laminae
Mean	16.4	0.5	0.1	0.5	4.8	71.0	4.5	2.2	47	75
Min.	2.5	-	-	-	-	7.5	1.0	-	10	10
Max.	57.0	3.0	1.0	5.0	21.0	94.5	9.5	16.0	81	187

T = trace

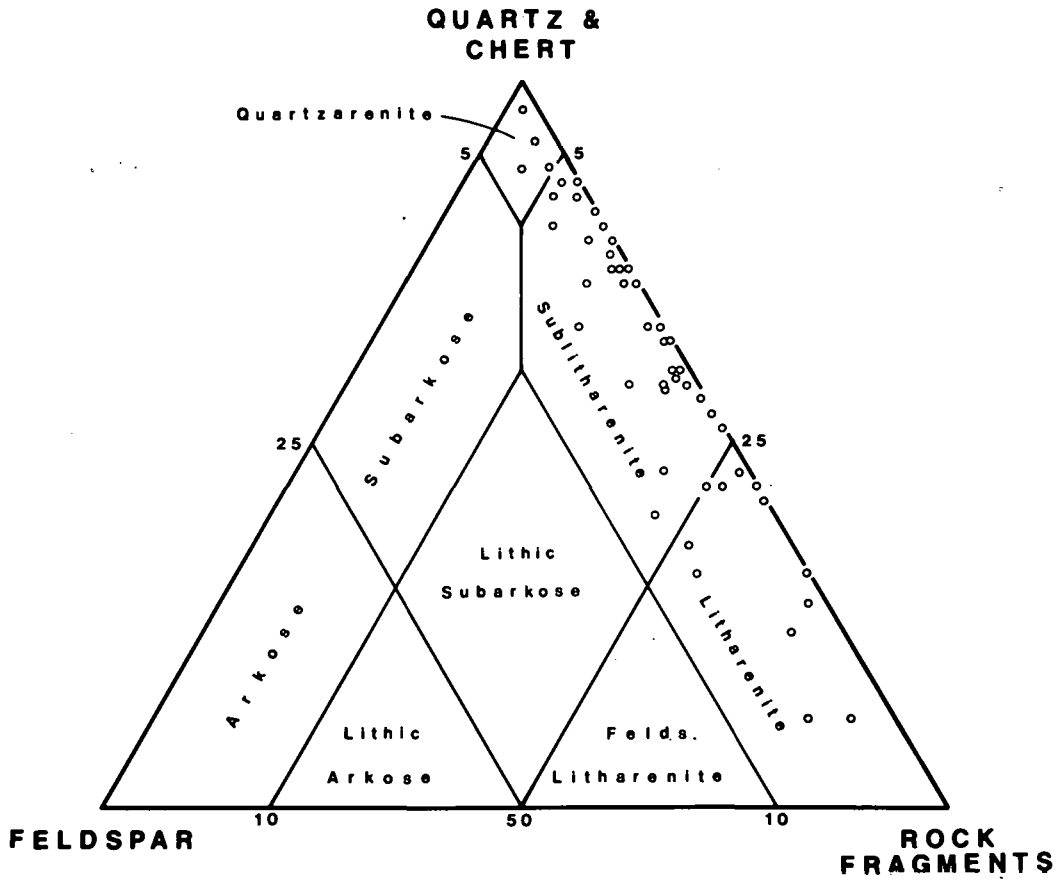


Figure 4. Triangular plot of quartz plus chert, rock fragments, and feldspars of the Brallier Formation siltstones. Classification is that of McBride (1963). Notice that only the upper half of the McBride triangular classification is used. Sixty-two observations.

Figure 5. A. Quartz-mica schist fragment in siltstone. Note elongate quartz grains and well-developed foliation. Brallier Formation.

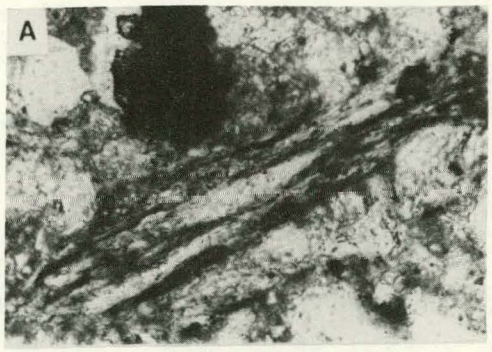
B. One of the few sandstones observed in the Brallier Formation is mainly angular to subrounded quartz grains with carbonate cement. Note elongate quartz grains and tourmaline grain in middle right.

C. Carbonate cement replacing chert grain in siltstone. Note rhombohedral crystal faces of carbonate cement at grain margin. Brallier Formation.

D. Discontinuous silt laminae in black mudshale. Matrix is clay and amorphous organic matter. Brallier Formation.

E. Nearly silt-free clayshale. Collapsed, chertified spore in lower-right. Brallier Formation.

F. Strongly bioturbated mudstone. Brallier Formation.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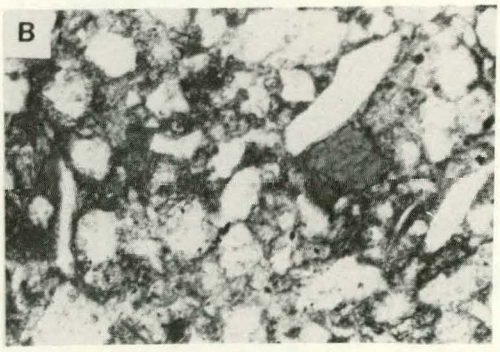
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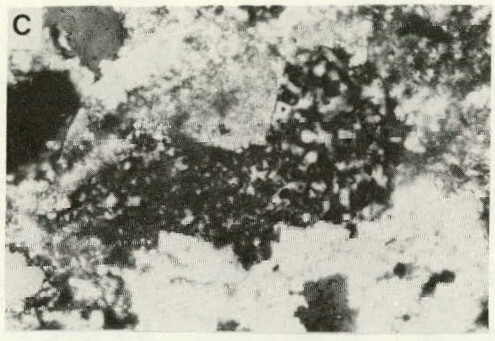
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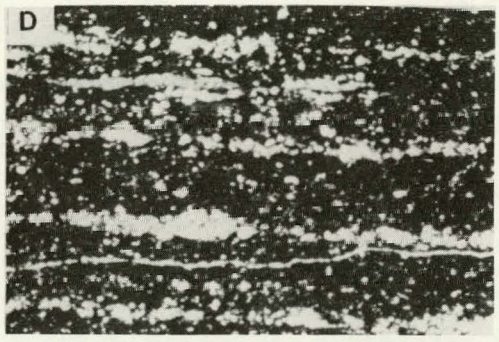
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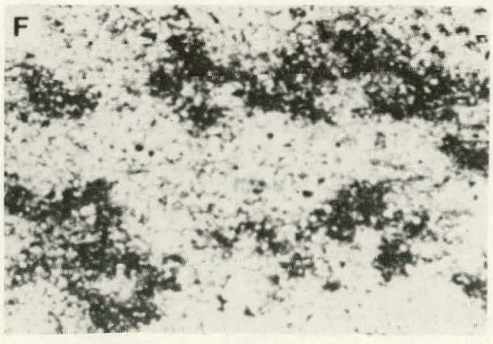
F
0.5 mm

Rock fragments are relatively abundant in the siltstones of the Brallier Formation and were subdivided into the following categories: metamorphic, quartz-polymineralic, chert, siltstone, "shale", and carbonate. Metamorphic rock fragments, by far the most abundant type, consist primarily of chlorite-muscovite-quartz schists or phyllites with well developed foliation (see Fig. 5A). The fragments classified as quartz-polymineralic exhibit no foliation and consist of polycrystalline grains of quartz and/or feldspar with significant amounts of mica. The "shale" fragments, similar in all respects to "shales" interbedded with the siltstones, are interpreted as locally derived rip-up clasts. Chert grains are relatively common and occur as a light colored, coarse-grained variety (individual microcrystals 2 to 4 microns, see Fig. 5C). Both siltstone particles and carbonate fragments are rare.

Micas include muscovite, chlorite, and biotite. Muscovite, ubiquitous in the siltstones, is by far the most abundant. Chlorite, although present in most samples, rarely exceeds a few percent. The rare flakes of biotite are generally somewhat weathered.

The matrix, composed mainly of illitic and chloritic clay, appears to be predominantly detrital in origin (protomatrix of Dickinson, 1970), although some may be derived from squashed rock fragments (pseudo-matrix of Dickinson, 1970). It appears olive drab in white light and shows low-order yellow or orange birefringence in polarized light. Matrix in weathered samples is commonly reddish or brownish.

Heavy minerals of the Brallier Formation, which occur only in

trace amounts, include zircon, tourmaline, and rutile. The grains tend to be rounded and are probably recycled.

The petrographic features of the Brallier Formation siltstones and their paleocurrents (see Fig. 9) suggest that they had an eastern source of low-grade metasedimentary and sedimentary rocks. Many such rocks of pre-Brallier age crop out east of the Brallier outcrop belt in the Blue Ridge and Piedmont Provinces. These include, for example, the Blue Ridge complex and the Wissahickon schists and gneisses. Ethridge's (1978) data on the petrology of Upper Devonian turbidites in New York suggests that they too had a source of metasedimentary and sedimentary rocks.

The fresh plagioclase and chlorite grains in the Brallier Formation siltstones suggest that weathering was inhibited in the source area. The abundance of wood fragments, however, suggests that at least part of the source area, perhaps only the coastal plain, was moist. This observation contradicts the contention of Woodrow and others (1972) that the southern Appalachians were desert-like in Late Devonian time. A relatively proximal source with moderate relief could produce fresh plagioclase and chlorite grains even if the climate were moist.

The petrographic suite of components in the siltstones is present in the other mudrocks of the Brallier Formation but their relative abundances are quite different (Tables 1 and 2).

Quartz, which is found in every mudrock, almost always occurs as angular monocrystalline grains. A few grains of plagioclase are observed in most samples, but other feldspars are rarely encountered. In

some siltstones, especially in Tennessee, grains of quartz and feldspar occur in two modes: disseminated throughout the clay and concentrated in thin laminae (Fig. 5D). These laminae often exhibit the "annealed" appearance typical of many of the siltstones. Maximum grain size in the mudrocks ranges from 40 to 90 microns and averages 65 microns or one-third to one-half the maximum grainsize of the siltstones (Table 2). The disseminated silt particles are generally finer-grained than those in laminae.

Rock fragments in the mudrocks of the Brallier are the same variety as those in the siltstones but they are observed only very rarely. Their scarcity probably reflects the finer grain size of the mudrocks: that is, only rock fragments composed of very fine grains are represented. In this size range foliated rock fragments are difficult to distinguish from the fine-grained clay matrix in which they occur.

Muscovite is as abundant in the mudrocks as in the siltstones, although finer-grained. Chlorite and biotite are rare.

Clay minerals, predominantly illite and lesser chlorite, comprise the bulk of all the Brallier mudrocks. Clay mineralogy was determined by X-ray diffraction. In thin section, clay is olive or grayish in white light and shows low-order orange to yellow birefringence in polarized light. In weathered samples the clay has a reddish-brown color. The orientation of clay particles ranges from nearly random in burrow, mudstones and claystones (Fig. 5F), to strongly preferred in shales with megascopic textural lamination. Degree of orientation was qualitatively estimated according to how closely the clay particles

approached mass extinction as the microscope stage was rotated.

Organic matter occurs in three forms: disseminated brown amorphous material, discrete dark brown streaks, and spores. Pyrite commonly replaces the first two forms. Spores are generally flattened parallel to bedding and chertified (Fig. 5E).

Elemental Analysis

Forty-four mudrock samples from the Brallier Formation and the Millboro Shale, which underlies the Brallier Formation in Virginia, were analyzed for organic carbon, nitrogen, and hydrogen with a Perkin Elmer 240 Elemental Analyzer. Carbonate carbon was removed by acid dissolution and the percent C, N, and H in the remaining insoluble residue was calculated by the following formula:

$$\% x = \frac{\text{weight of sample}}{Kx\ (mv)}$$

Kx is a calibration factor determined for a standard sample of known composition, and (mv) is the instrument reading in millivolts, corrected to the net output. The percent C, N, and H in the insoluble residue were then corrected to their whole rock values. These values are accurate to $\pm$ 0.01 percent. In general, the upper Millboro Shale has higher organic carbon content than do the mudrocks of the Brallier Formation, although the few dark colored shales in the Brallier are as rich in organic carbon as those in the Millboro (Table 3). We interpret this to indicate that the base-of-slope, where the Brallier turbidites were deposited, marked the transition from dominantly anerobic to dysaerobic conditions. Associated with this change in organic carbon

content is a change in the color of the mudrocks from olive gray mudstones, claystones, and shales of the Brallier Formation, to dark gray to black shales of the Millboro Shale.

Lithologically distinct mudrocks of the Brallier Formation are for the most part distinct in their C, N, and H contents (Fig. 6). There is little variation in the percent nitrogen, regardless of lithology. Hydrogen in these samples occurs mostly in water in clays, so the C/H ratio is a measure of the organics/clay ratio. Dark gray to black shales occupy a distinct field in Figure 6 characterized by high organic carbon content. Bioturbated yellowish gray claystones and olive gray mudrocks, however, plot in the same field. Both are characterized by low organic carbon content. Medium gray shales are of intermediate organic carbon content and plot between the other two fields. The dark color of the black shales is an indication of their high organic content and the medium gray shales simply contain less organic matter. The bioturbated yellowish gray claystones and olive gray mudrocks have different facies relationships as discussed in a later section. Therefore, the fact that they plot in the same field in Figure 6 suggests that organic carbon content of muds is not controlled solely by depositional environment.

Few of the samples in Table 3 contain sufficient organic matter to be considered good source rocks for oil or gas; however, farther west in the subsurface, turbidite siltstone bundles are interstratified with shales having high organic contents (Cheema, 1977). These occurrences may make attractive source bed-reservoir packages.

TABLE 3

Part A

ORGANIC CARBON, NITROGEN, AND HYDROGEN ANALYSES

STRAT. UNIT	SAMPLE NUMBER	PERCENT WHOLE ROCK C	N	H
BRALLIER FORMATION	BS1-54.8	0.27	0.06	0.46
	BS1-59.6	0.18	0.07	0.50
	BS1-70.3	0.19	0.04	0.37
	BS1-85	0.09	0.00	0.45
	BS2-100	1.13	0.11	0.45
	BS4-32	1.10	0.03	0.48
	GC1-1	0.15	0.08	0.40
	HG1-4	2.59	0.47	0.55
	HI1-1	0.37	0.10	0.51
	MC1-1	0.20	0.14	0.55
	MC1-13	0.12	0.09	0.44
	MH2-5	0.05	0.17	0.41
	McD-182	0.24	0.06	0.47
	R16-BLK	1.05	0.11	0.57
	ST1-36	0.10	0.12	0.50
	ST1-37	0.23	0.05	0.46
	ST1-38	0.00	0.07	0.29
	ST1-42	0.14	0.06	0.61
	ST1-43	0.05	0.13	0.56
	ST1-45	0.05	0.11	0.52
	ST1-46	0.05	0.06	0.56
	ST1-53	0.85	0.10	0.59
	ST1-54	0.86	0.11	0.45
	ST1-60	0.14	0.03	0.36
	ST1-67	0.11	0.04	0.43
	ST1-73	0.08	0.04	0.44
	ST1-75	0.31	0.10	0.58
	ST1-77	0.49	0.17	0.47
	ST1-78	0.32	0.04	0.47
	ST2-149	0.19	0.17	0.50
	ST3-817	0.20	0.06	0.50
	ST3-888	0.21	0.03	0.48
	ST3-893	0.68	0.15	0.31
MILLBORO SHALE	BS1-4.5	2.13	0.09	0.42
	BS1-34.6	0.18	0.07	0.41
	BS1-43.7	0.37	0.11	0.51
	BS1-48.7	0.24	0.07	0.41
	BR1-2	1.58	0.14	0.52
	BR1-3	0.91	0.16	0.49
	ST1-31	0.20	0.09	0.53
	ST1-32	0.19	0.09	0.41
*	PH1-1	0.54	0.07	0.32
	TO-6	0.09	0.04	0.47
**	R16-BSG	1.10	0.13	0.48

* Chattanooga Shale

** Price Formation, Big Stone Gap Shale Member of Bartlett (1974).

TABLE 3

Part B

LOCATIONS OF SAMPLES

SAMPLE	LOCATION
BS1-54.8	Bastian Section; 0.3 ft above base of unit 2.
BS1-59.6	Bastian Section; 5.1 ft above base of unit 2.
BS1-70.3	Bastian Section; 7.4 ft above base of unit 2.
BS1-85	Bastian Section; 5.0 ft above base of unit 3.
BS2-100	Bastian Section; 100 ft above base of unit 5.
BS4-32	Bastian Section; 6.5 ft below top of unit 18.
GC1-1	Nottingham Section; 110 ft above base of unit 1.
HG1-4	Hayters Gap Section; 2.5 ft above base of unit 20.
HI1-1	Hilton Section; 11.4 ft above base of unit 1.
MC1-1	Gauley Ridge Section; 23 ft above base of unit 5.
MC1-13	Gauley Ridge Section; 23 ft above base of unit 5.
MH2-5	Minnehaha Springs Section; 10 ft below top of unit 7.
McD-182	McDowell Section; middle of unit 30.
R16-BLK	Virginia Route 16 Section; unit 32.
ST1-36	Cloyds Mountain Section; top of unit 3.
ST1-37	Cloyds Mountain Section; 1.6 ft below top of unit 4.
ST1-38	Cloyds Mountain Section; base of unit 5.
ST1-42	Cloyds Mountain Section; 2.8 ft above base of unit 6.
ST1-43	Cloyds Mountain Section; 8.1 ft above base of unit 6.
ST1-45	Cloyds Mountain Section; 9.2 ft above base of unit 6.
ST1-46	Cloyds Mountain Section; 10.3 ft above base of unit 6.
ST1-53	Cloyds Mountain Section; 8.5 ft above base of unit 7.
ST1-54	Cloyds Mountain Section; top of unit 7.
ST1-60	Cloyds Mountain Section; 8.5 ft above base of unit 12.
ST1-67	Cloyds Mountain Section; 79.9 ft above base of unit 16.
ST1-73	Cloyds Mountain Section; 12.1 ft below top of unit 16.
ST1-75	Cloyds Mountain Section; 12.9 ft above base of unit 18.
ST1-77	Cloyds Mountain Section; 13.2 ft above base of unit 24.
ST1-78	Cloyds Mountain Section; 11.5 ft above base of unit 27.
ST2-149	Cloyds Mountain Section; 20 ft above base of unit 38.
ST3-817	Cloyds Mountain Section; 8 ft above base of unit 53.
ST3-888	Cloyds Mountain Section; 1 ft below top of unit 60.
ST3-893	Cloyds Mountain Section; 4 ft above base of unit 61.
BS1-4.5	Bastian Section; 4.5 ft above base of unit 1.
BS1-34.6	Bastian Section; 34.6 ft above base of unit 1.
BS1-43.7	Bastian Section; 43.7 ft above base of unit 1.
BS1-48.7	Bastian Section; 48.7 ft above base of unit 1.
BR1-2	Broadford Section; 15 ft above base of unit 3.
BR1-3	Broadford Section; 38 ft above base of unit 3.
ST1-31	Cloyds Mountain Section; 7.5 ft above base of unit 1.
ST1-32	Cloyds Mountain Section; 17.5 ft above base of unit 1.
PH1-1	Little War Gap Section; 26 ft above base of unit 7.
TO-6	U.S. Highway 25-E Section; 4 ft above base of unit 10.
R16-BSG	Virginia Route 16 Section; 175 ft above top of unit 60.

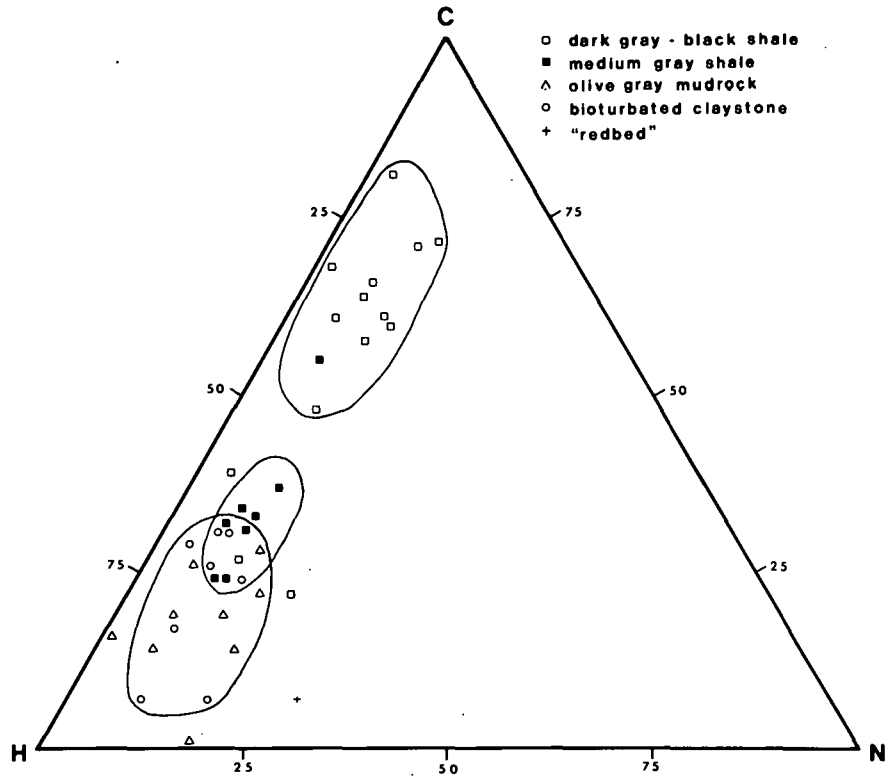

Figure 6. Triangular plot of organic carbon, nitrogen, and hydrogen contents of mudrocks recalculated to 100 percent.

SEDIMENTOLOGY

Sedimentologic study included work in both the field and the laboratory. Important aspects of this work included the measurement of directional sedimentary structures and the description of approximately 23,000 feet of section in the field, mostly during the summer and fall of 1978 (please see Appendix 1 for measured sections). This work constitutes the heart of our study and provided the basic data for most of our conclusions.

Paleocurrents

Approximately 700 directional structures were measured in the Brallier Formation and related rocks in Virginia, West Virginia, and east Tennessee. Of these, 560, or 80 percent are substratal markings, including flute and groove molds (Figs. 7 and 8), prod and bounce marks, and ridge and furrow structure. The remainder are mostly ripple marks but include elongate wood fragments, parting lineations, and cross bedding. These data are distributed over eight-five 7-1/2 minute quadrangles at an average density of eight observations per quadrangle.

Approximately 90 percent of the data are from the Brallier Formation, the rest are from the "Chemung" Formation, Scherr Formation, and Chattanooga Shale (east Tennessee data). Many more observations of sole mark orientations were made than other directional structures because they are more precise indicators of turbidite flow patterns (Potter and Pettijohn, 1977, p. 172).

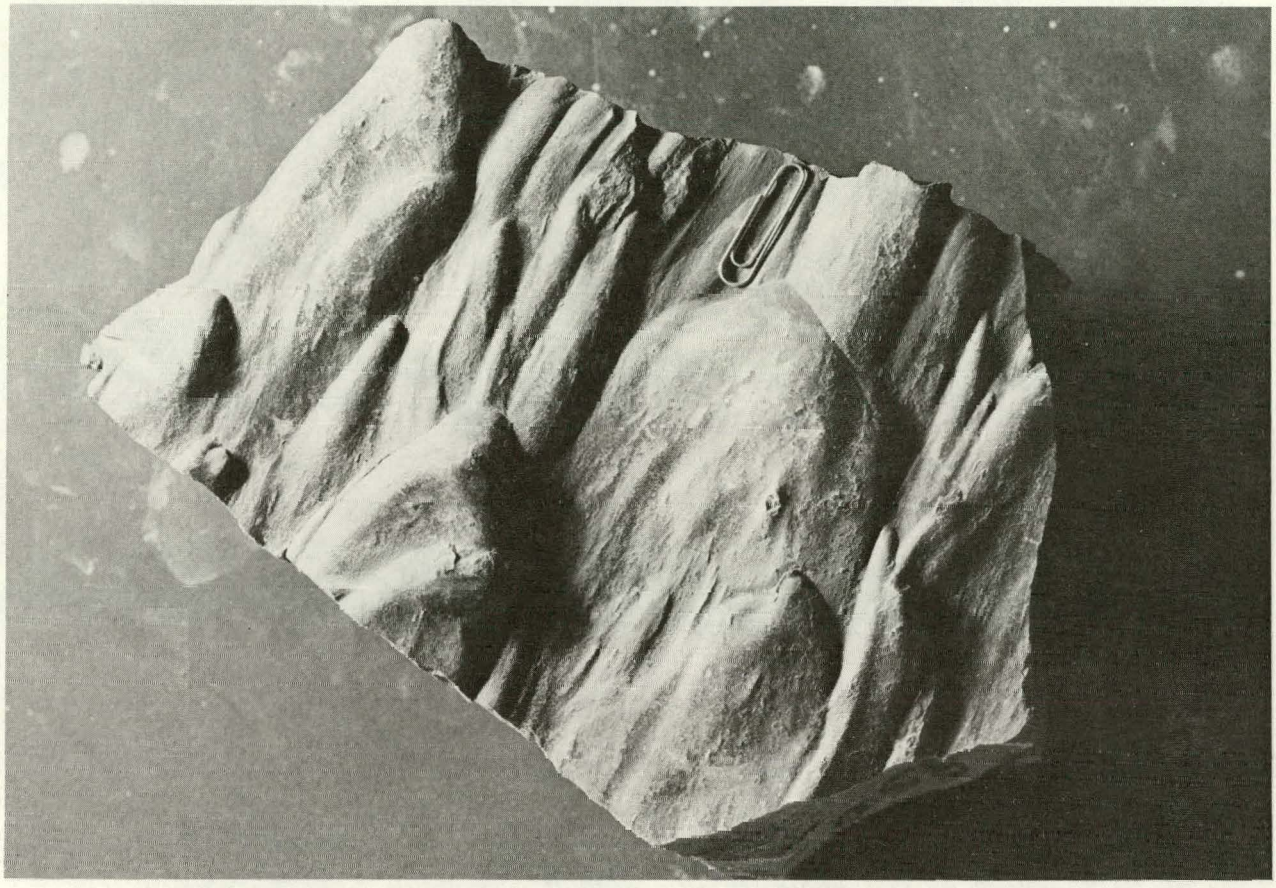

Figure 7. Flute molds in siltstone of Brallier Formation. Current from upper right to lower left. Sample from unit 40, Bastian Section (Section 22 in Appendix).

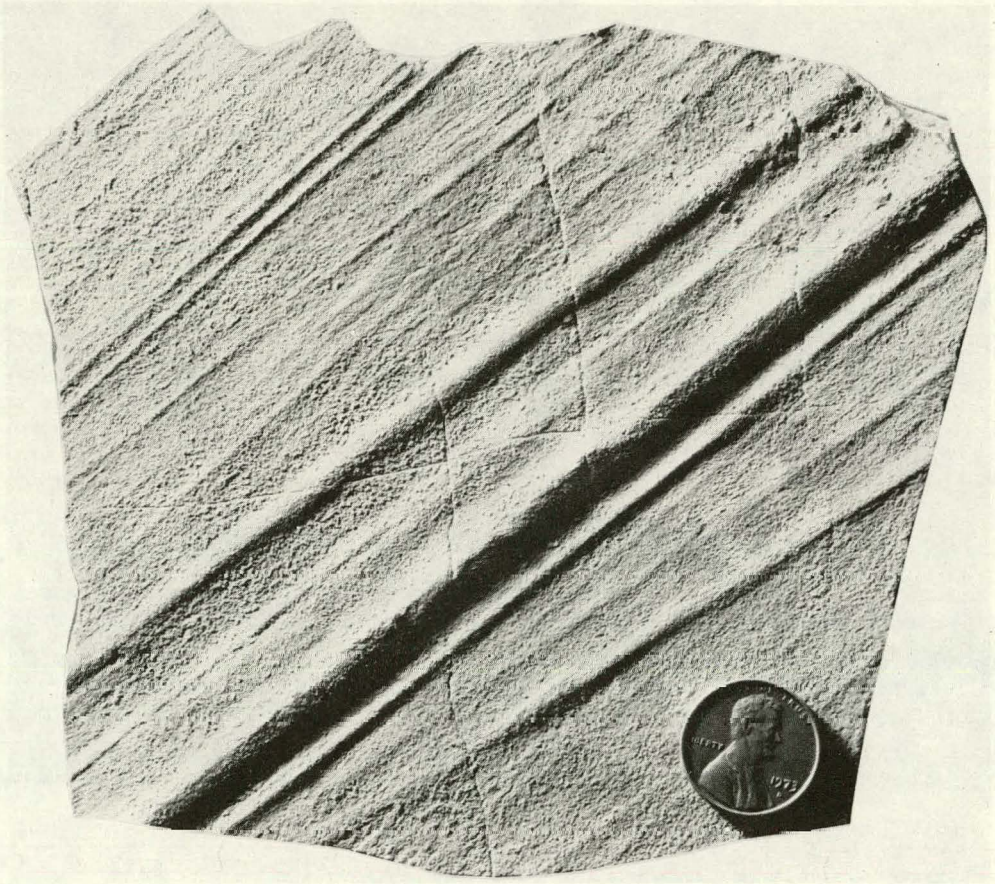

Figure 8. Groove molds in siltstone of Chattanooga Shale. Sample from unit 9, Flat Gap Section (Section 13 in Appendix).

Regionally, the Brallier Formation paleocurrents show a homogeneous westerly trend (Fig. 9), perpendicular to the north-south depositional strike (Dennison and Hasson, 1976, p. 278), and transverse to the axis of the depositional basin. This trend shows little variation from central Pennsylvania to eastern Tennessee, a distance of approximately 350 miles along depositional strike. In addition, Upper Devonian turbidite paleocurrents are very similar in New York state (Sutton, 1959; McIver, 1970; Potter and others, in press), indicating the same dispersal pattern persists for nearly 450 miles along depositional strike. Absent are indications of any longitudinal flow (parallel to the basin axis) which, according to Potter and Pettijohn (1977, p. 332), is the rule in most turbidite systems.

What effect does averaging the raw data have on the patterns observed, i.e., how much has the data been smoothed? Figure 10 shows that the data are consistent whether averaged over 30 minute quadrangles, 7-1/2 minute quadrangles, or individual outcrops. Even if all of the data from substratal lineations in Virginia, West Virginia, and Tennessee are plotted on a single rose diagram (Fig. 11) a remarkable distinct unimodel distribution results, demonstrating that even over large areas the paleocurrents show little variation.

The areal homogeneity for more than 350 miles along depositional strike strongly suggests that turbidity currents had multiple point sources of origin. As a submarine fan grows, it becomes a topographically positive feature which induces flow divergences because of its subarcuate slopes. Had there been only a few sources, distinct dispersal patterns radiating from these points should be evident (see Sullwold,

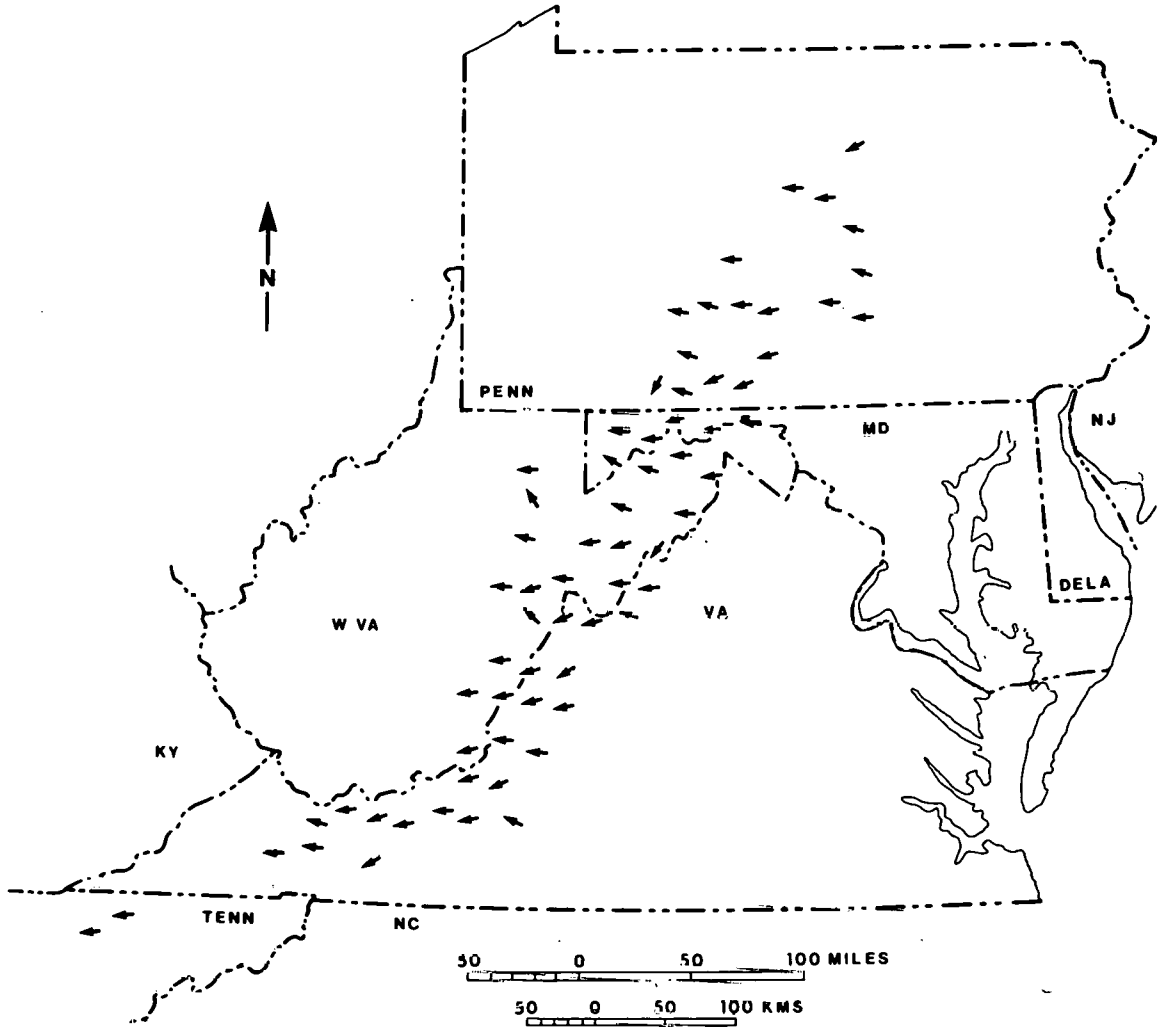

Figure 9. Paleocurrent map of Devonian turbidites of the Appalachian basin showing the orientation of paleocurrents in the Brallier Formation from Pennsylvania south to Tennessee. Each arrow represents the vector mean of data within a 15-minute quadrangle. Note consistent westerly trend for 400 miles (600 kms) along depositional strike. Data in Pennsylvania and Maryland was collected by McIver (1970, Figure 14; and written communication).

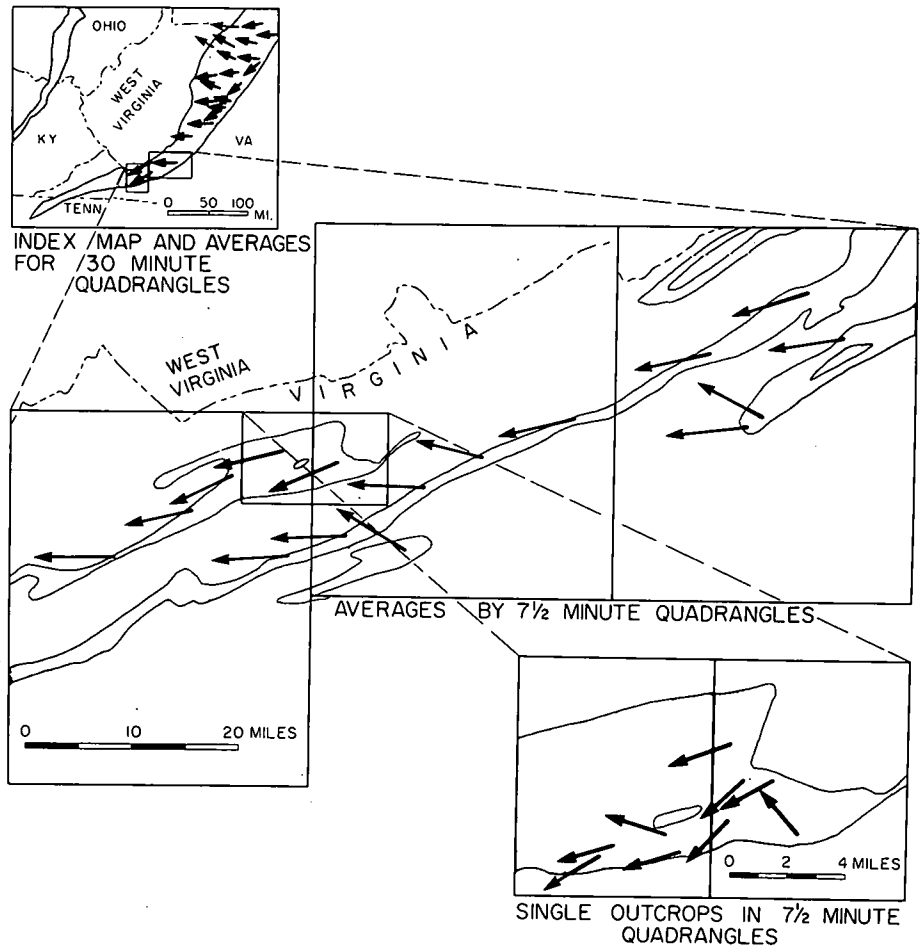

Figure 10. Paleocurrent data averaged at three different scales. Note consistency of trend in each example. Outcrop pattern of the Brallier Formation is shaded.

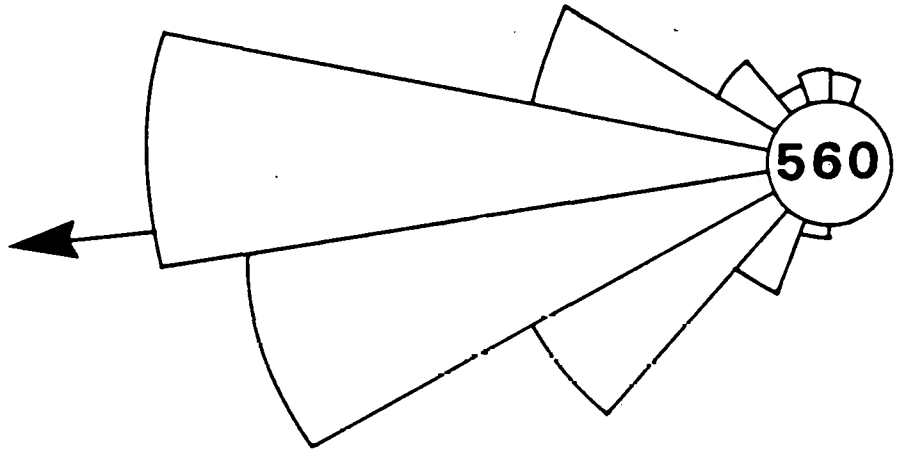

Figure 11. Rose diagram of all sole mark observations (560) and vector-mean.

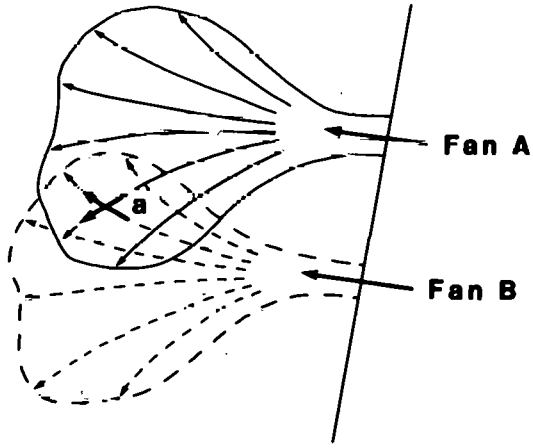

Figure 12. Sketch shows how two overlapping fans may have divergent flow patterns. The divergent flow patterns of fan A and B should be detectable in vertical profiles.

1960).

The paleocurrent maps of Figures 9 and 10 summarize data from different stratigraphic horizons. Marker beds have not been recognized in the Brallier Formation and are generally absent in turbidite sequences (Pettijohn and others, 1972, p. 500). Also the orientation of outcrops precluded following beds down the dip of the sedimentation into the basin. Because of this it was impossible to investigate the areal variations of paleocurrent patterns in rocks representing small time intervals, of say several hundred thousand years. How then is it possible to determine whether the homogeneous pattern in Figure 9 is the result of averaging divergent paleocurrent patterns of narrow stratigraphic range? This question can be answered by examining the trends of directional structures in vertical profiles. Suppose the deposits at a given place on the sea floor were formed by the coalescence of a few large long-lived submarine fans, then divergent paleocurrent patterns associated with each fan ought to be seen in a vertical profile through the deposit (Fig. 12). Vertical profiles of Brallier paleocurrents show an overall uniformity and absence of distinct divergent trends (Figs. 13 and 14). Irregular variations are predominantly less than 20°. Therefore, we suggest that the Upper Devonian paleoslope was one of little topographic relief on which elongate turbidite lobes extended down the paleoslope, and were continually built and abandoned as the loci of turbidity currents shifted.

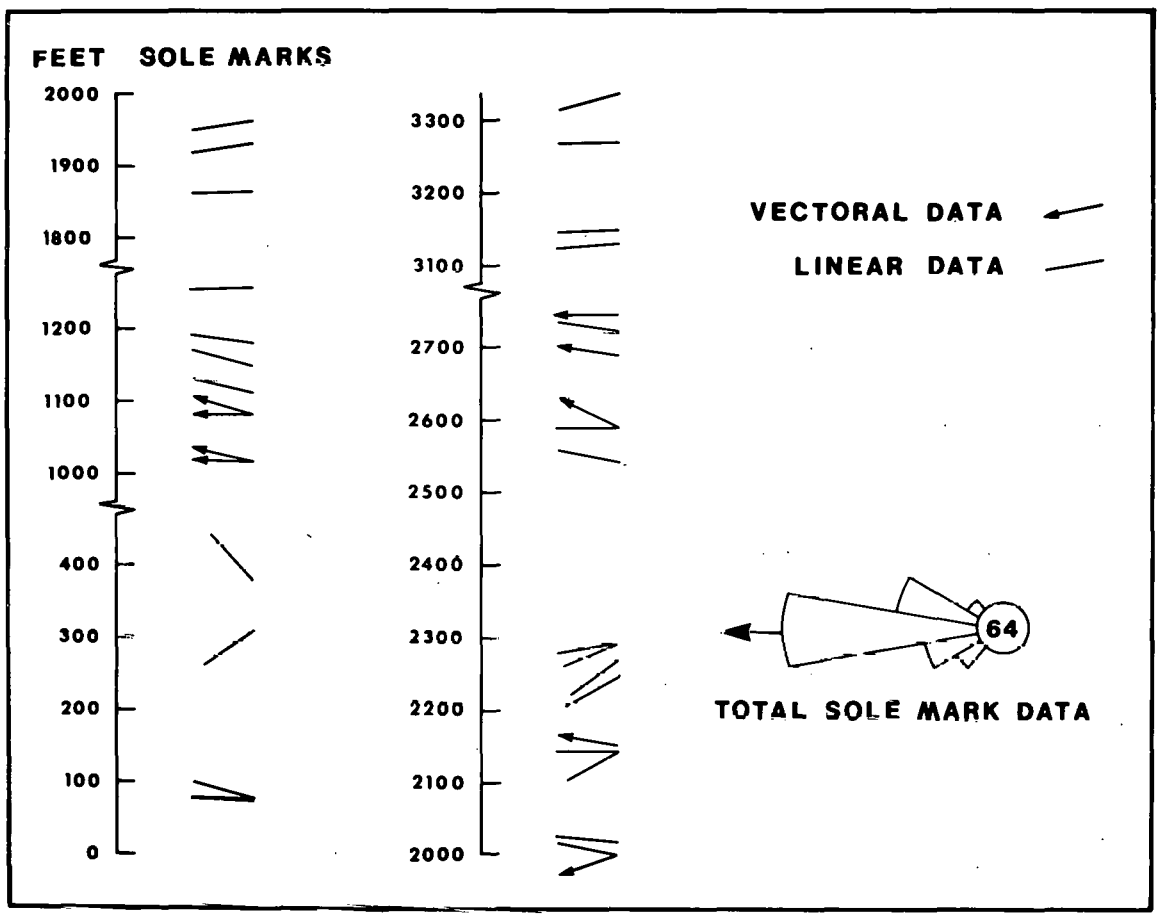

Figure 13. Vertical profile of paleocurrents in Brallier Formation, Cloyds Mountain Section (Section 18 in Appendix). Note overall uniformity.

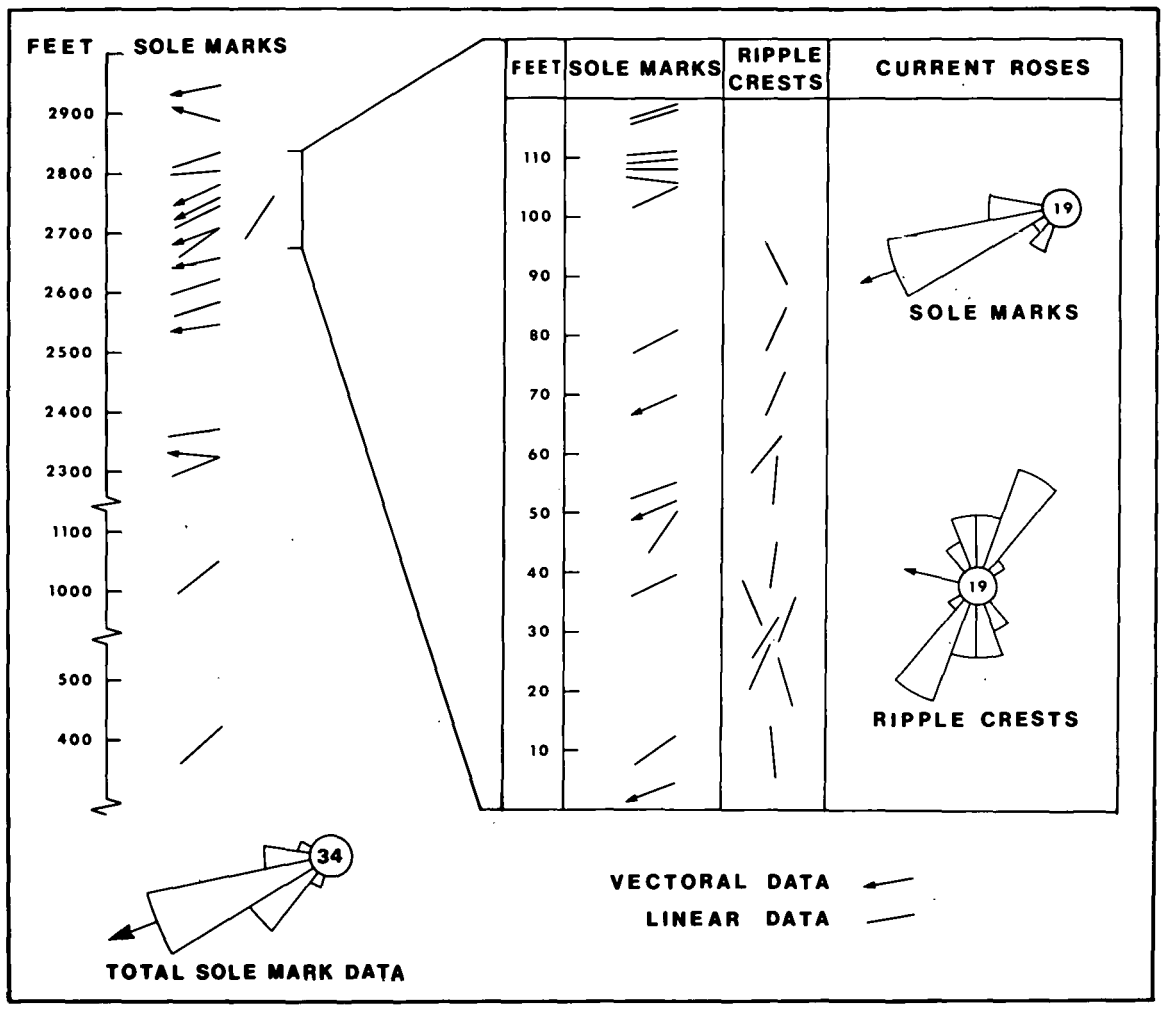

Figure 14. Vertical profile of paleocurrents in Brallier Formation, Bastian Section (Section 22 in Appendix). Note overall uniformity.

Facies

Facies analysis has proven useful in interpreting the origin, distribution, and internal relationships of the Brallier Formation as well as the entire Upper Devonian clastic sequence in the southern part of the Appalachian basin. Our analysis is based on observations made during the measurement and description of thirty-five sections and at over fifty other localities where section was not measured although some data were obtained. Additional data were collected from the two eastern Tennessee cores.

We have distinguished six lithofacies of the Brallier Formation and vertically adjacent strata by gross lithology, silt/shale ratio, bedding thickness and character, and physical and biogenic structures. The names we assigned to these facies are: delta front, turbidite slope, siltstone bundle, interlobe slope, lobe margin, and basinal black shale. Their salient features are summarized in Table 4.

Delta Front Facies

High sand to shale ratio, thick beds, lenticular bedding, cross-bedding (Fig. 15), and abundant and diverse marine fossils in the sandstone beds of this facies (Table 4) indicate a shallow, current-agitated environment. Fossils include abundant crinoids and brachiopods, and fewer molluscs. Common coquina lenses at the base of cross-bedded strata indicate winnowing of the sea floor, and thickening- and coarsening-upward sequences indicate cycles of facies progradiation. The delta front facies comprises the upper-most part of the Brallier

TABLE 4

SUMMARY OF FACIES

FACIES	LITHOLOGY AND THICKNESS	SILT/SHALE	BED THICKNESS OF COARSEST GRAINED UNIT	SEDIMENTARY STRUCTURES
Delta front	Fine-grained sandstone to siltstone and olive gray mudstone. 10's - 100's of m.	Moderate to very high	$\bar{X}$ 30 cm R 10 cm - 2 m	Lenticular to irregular bedding, cross bedding, fossiliferous (moderately abundant and diverse), coquinas common. Coarsening- and thickening-upward sequences.
Turbidite slope	Siltstone and olive gray mudstone or shale 3 - 30 m.	Low to high	$\bar{X}$ 6 cm R 1 - 30 cm	Even persistent beds with base-truncated Bouma sequences (*tbcde*, *Tcde*) common, tops of beds commonly rippled, organic and inorganic sole marks very common. Coarsening- and thickening upward sequences in upper part of the Brallier Formation
Siltstone bundle-Channel deposit?	Siltstone to very-fine-grained sandstone with minor shale. 5 - 22 m.	High to very high	$\bar{X}$ 10 cm R 2 cm - 1.5 m Beds greater than 30 cm are characteristic.	Even, sharply defined beds; structureless non-graded beds common; *Ta*, *Tab*, and *Tabc* Bouma sequences; tops of beds may be rippled and slightly gradational with overlying shale; shale clasts and bed amalgamation common; sole marks generally uncommon; rare load structures. Most bundles show fining- and thinning-upward sequences.
Interlobe slope	Olive gray mudstone and minor shale 3 - 60 m	0 to very low	$\bar{X}$ 3 cm R 1 - 10 cm	Mudstone: distinct horizontal burrows, 3-5 mm wide; some tracks resembling Pteridichnites biseriatus; Ambocoelia sp. Siltstone: base-truncated Bouma sequences (*Tcde*, *Tde*); tops of beds commonly rippled.
Lobe margin	Olive gray to dark gray silt-laminated shale, and minor yellowish gray burrowed claystone. 15 cm - 210 m	0 to very low	Less than 3 cm, if present. Silt laminae 1-2 mm thick are very common	Shale: even, persistent silt laminae less than 2 mm thick are very common; siderite layers up to 2 cm thick locally common. Claystone: distinct to indistinct horizontal burrows less than 2 mm wide, giving mottled appearance where disseminated and biolamination where concentrated in layers.
Basinal	Black shale Up to 30 m	0 to very low	$\bar{X}$ 3 cm R 1.5 - 10 cm	Shale: dominantly clayshale with textural lamination; silt laminae less than 2 mm thick locally common. Siltstone beds, if present, generally have *Tce* Bouma sequence and rippled tops.

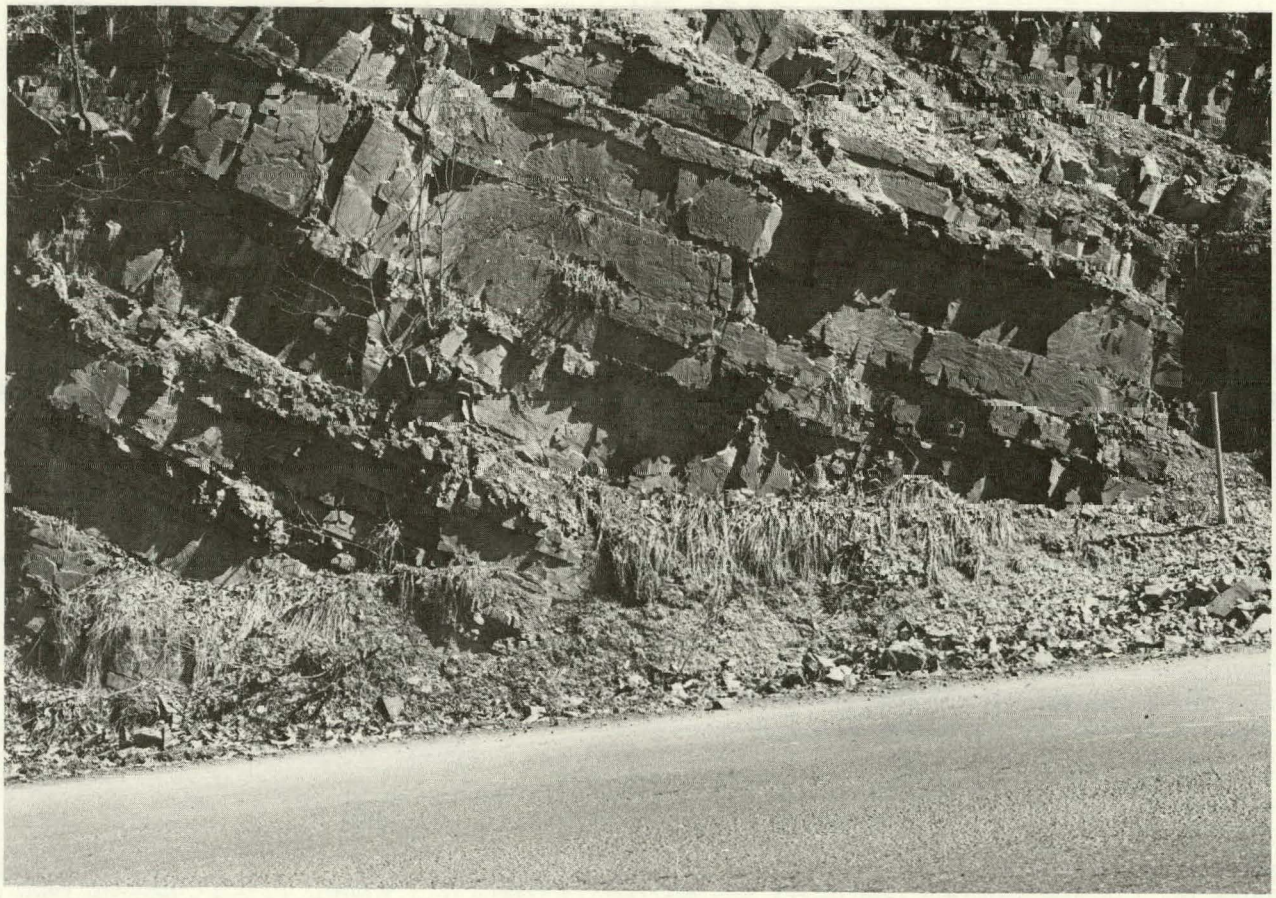

Figure 15. Delta front facies. Note high sand/shale ratio and thick beds. Brallier Formation, Cloyds Mountain section, unit 54 (Section 18 in Appendix). Mattock handle is 1 m long.

Formation and the lower part of the "Chemung" Formation. This facies is conformably overlain by non-marine red beds of the Hampshire Formation in the northern part of the study area and thins distally to the west and south. The delta front facies are not present in eastern Tennessee. Several shallow-water, nearshore environments have been recognized in the Foreknobs Formation along the Allegheny Front in West Virginia (cited in McGhee, 1975, p. 133). These include shelf, sand bar, and bar protected environments. The Foreknobs Formation comprises part of the strata formerly called the "Chemung Formation" in West Virginia.

Turbidite Slope Facies

Thin bedding, moderate to high silt to shale ratio, and base-truncated Bouma sequences (Bouma, 1962) in the siltstone beds of the turbidite slope facies (Table 4, Fig. 16) indicate that small to medium turbidity currents frequently interrupted the more or less continuous hemipelagic sedimentation of mud. The delta front facies overlies and is gradational with the turbidite slope facies which also thins distally and is absent in southwestern Virginia and eastern Tennessee. The turbidite slope facies is commonly recurrent in long stratigraphic sections and shows variable silt to shale ratios. Bed thickness and silt to shale ratio generally increase up section, indicating an increase in proximity to the source. This increase in proximity was accompanied by an increase in oxygenation of the water column as indicated by the occurrence of a few vertical feeding burrows in the

Figure 16. Turbidite-slope facies. Note even, persistent siltstone beds. Brallier Formation, Cloyds Mountain section, unit 34 (Section 18 in Appendix). Mattock handle is 1 m long.

siltstone beds. In the upper part of the Brallier Formation, thickening- and coarsening-upward sequences occur, but elsewhere megasequences are poorly developed in the turbidite slope facies. Soft bodied infauna were locally capable of reworking the mud deposited between turbidites, suggesting bottom conditions were generally dysaerobic. Sedimentary structures in the siltstone beds of the turbidite slope facies are typical of "distal" turbidites although stratigraphic evidence indicates some occur in proximally deposited turbidites.

Megasequences (i.e. thinning- and fining-upward or thickening- and coarsening-upward groups of beds in the turbidite-slope facies of the Brallier Formation are generally less conspicuous than those figures by Walker and Mutti (1973, Fig. 13 and 14) in the flysch of northern England and the northern Apennines of Italy. They involve less variation in bed thickness and grain size, and do not appear to be associated with major channeling. Inasmuch as the development of megasequences requires either steady progradation in an area or migrating channels, these data suggest frequently shifting sediment lobes on the slope and few or shallow channels.

Siltstone-Bundle Facies - Possible Channel Deposits?

Thickly-bedded bundles of siltstone are common features of the Brallier Formation (Fig. 17) and occur throughout the section, although they are most common in the lower half. Individual bundles range from about 10 to 73 feet in thickness and their lateral extent, parallel to depositional strike (estimated by tracing their topographic expres-

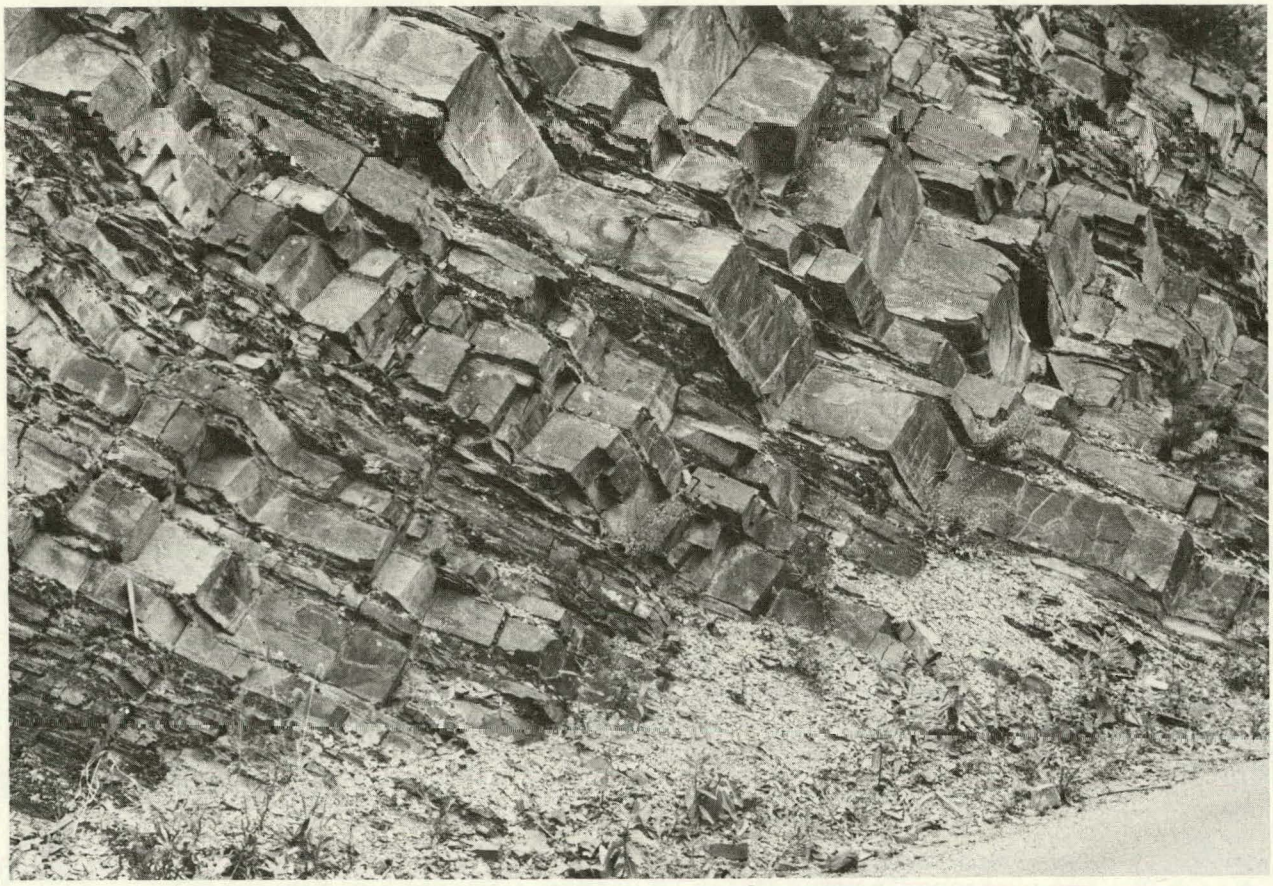

Figure 17. Turbidite siltstone bundle. Note abundance of thick, even siltstone beds. Hammer for scale in lower left. Brallier Formation, White Gate section, unit 2 (Section 19 in Appendix).

sion as linear ridges), is at most a few miles and generally less than 1 mile. Thick siltstone beds, high silt to shale ratio, top-truncated Bouma sequences, bed amalgamation, and the occurrence of shale clasts (Table 4) collectively indicate rapid deposition from relatively large, high flow intensity turbidity currents. Sole marks are rare in the siltstone bundles (Section 25 is an exception); however, the capacity of the turbidity currents to erode the bottom is demonstrated by many shale clasts, some up to 0.7 ft. long. They are lithologically identical to the interbedded shales. In vertical profile the siltstone bundles predominantly show thinning-upward sequences. Upward decreases in proximity indices accompany the thinning-upward trends, but are less well developed. In as much as thinning- and fining-upward sequences are evidence for channel filling (Walker, 1978, p. 953-956), these data indicate that siltstone bundles in the Brallier Formation are channel deposits. No channel margin features were observed, however. Subsurface data in West Virginia indicate that similar Upper Devonian turbidite bundles are elongate, linear bodies 15 to 60 ft. thick that trend perpendicular to depositional strike (Cheema, 1977). The lateral dimensions of siltstone bundles in the Brallier Formation are compatible with those of gullies on prodelta slopes (Shepard, 1955) and mid fan channels (Normark, 1978, p. 912). Available evidence suggests that these siltstone bundles are either the fill of shallow channels or simply thickly-bedded deposits formed along the axis of turbidite lobes.

Interlobe Slope Facies

The pervasive bioturbation of the mudstones, the sparse body fossils, and rarity of thin turbidite siltstone beds in the interlobe slope facies (Table 4, Fig. 18) suggest it was predominantly deposited by relatively slow hemipelagic sedimentation of mud in a dysaerobic sea floor environment. Ambocoelia sp. brachiopods are locally common in the mudstones but are thought to have been epifaunal sessile organisms (McGhee, 1975, p. 117), so bioturbation probably was the work of soft-bodied infauna. Mudstones have low organic carbon content, mostly less than 0.3 percent (Table 3 and Figure 6). Turbidite sedimentation was limited to a few thin siltstone beds with T_{cde} or T_{de} Bouma sequences, which we interpret to mean that the mudstones accumulated lateral to or basinward of the loci of turbidity currents. Repeated occurences of mudstone units 10 to 200 ft. thick between more "proximal" facies is more reasonably explained by lateral shifting of environments than by repeated cycles of facies progradation and retreat. We therefore interpret these mudstones as slope sediments which were deposited lateral to areas of active turbidite sedimentation.

Lobe Margin Facies

The lobe margin facies consists of bioturbated claystone and shale with abundant silt laminae (Table 4 and Fig. 19). This facies predominates in southwestern Virginia and eastern Tennessee. The silt laminae in this facies are interpreted as turbidites. They resemble

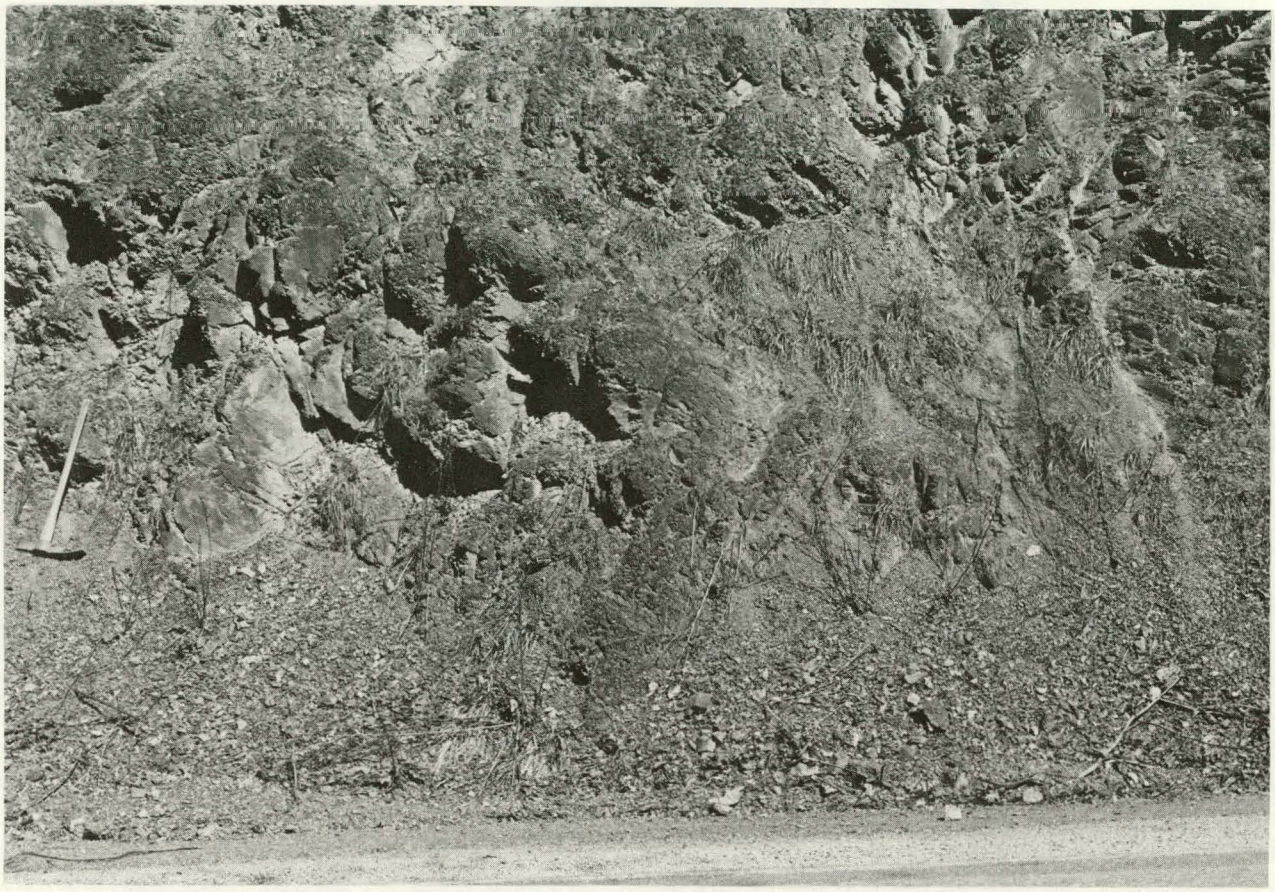

Figure 18. Interlobe slope facies. Note resistant mudstone and absence of siltstone beds. Brallier Formation, Cloyds Mountain section, unit 40 (Section 18 in Appendix). Mattock handle is 1 m long.

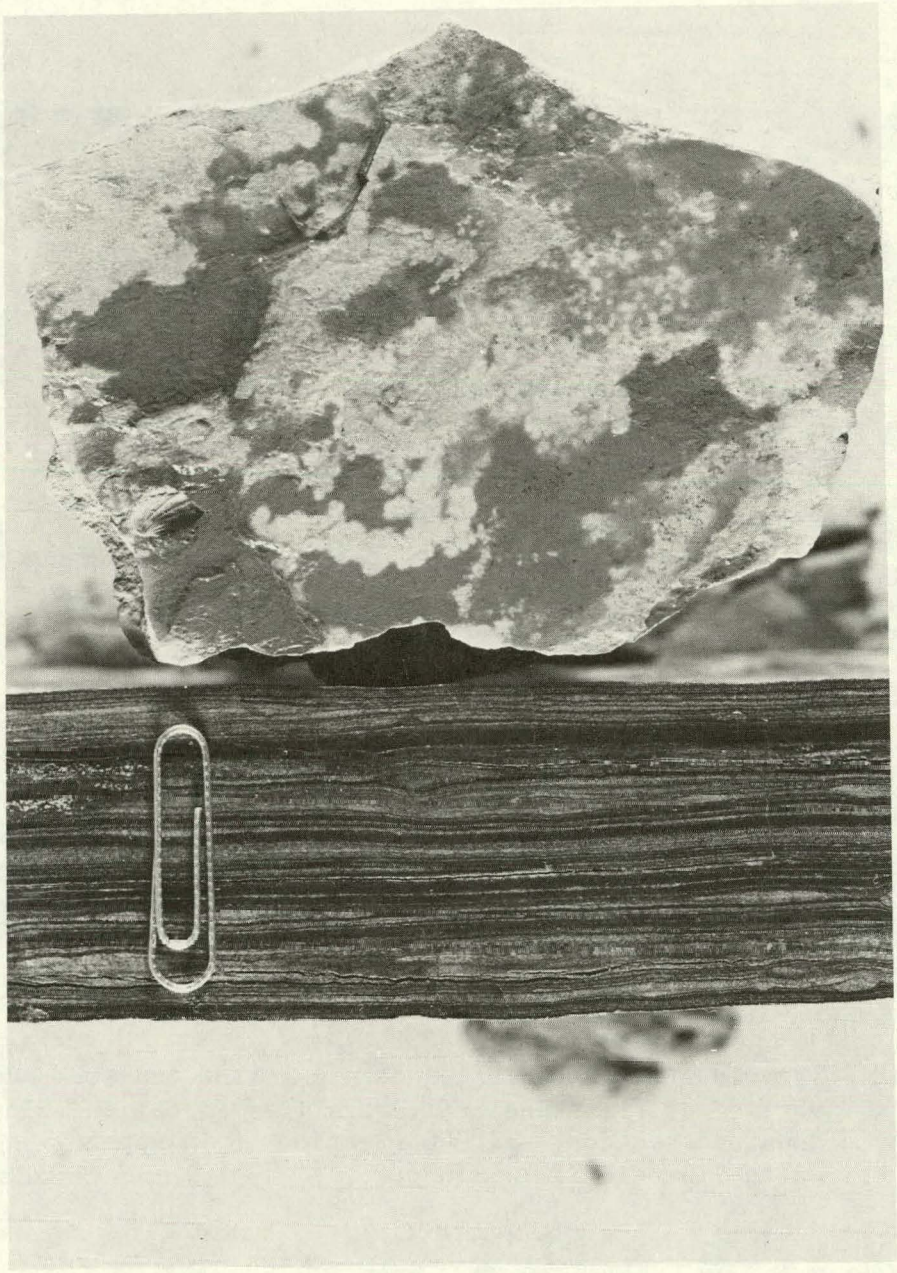

Figure 19. Lobe margin facies. Top: bioturbated claystone with yellowish gray burrow mottles. View is parallel to bedding. Perpendicular to bedding, the mottles appear as thin biolaminae and streaks. Bottom: shale with abundant silt laminae interpreted as turbidites.

in thickness and in the presence of graded individual laminae and graded groups of laminae, turbidite silt laminae described by Piper (1978, p. 165-166) on the Wilkes abyssal plain. Furthermore, shales with these silt laminae occur below units of turbidite siltstone beds in coarsening-upward sequences (please see Section 33 of Appendix). The near absence of siltstone beds and finer grain size of the shales and claystones in the lobe margin facies suggest that it was deposited in areas farther from active turbidite deposition than the interlobe-slope facies. The bioturbation in the claystones of the lobe margin facies is of smaller scale with smaller burrows than in the mudstones of the interlobe slope facies. Raff and Raff (1970) have shown that body size is inversely proportional to an organism's tolerance of anoxic conditions. Thus, the lobe margin facies was probably deposited in a more anoxic, more distal environment than the interlobe slope facies.

Basinal Facies

Basinal black shales containing few minor siltstone turbidites and locally common silt laminae (Table 4 and Fig. 20) occur in the lower part of the Brallier Formation and in the Millboro Shale in outcrops in southwestern Virginia. Subsurface data further indicate that this facies thickens westward and interfingers vertically with the eastern turbidite facies (Fig. 3). These black shales probably were deposited by hemipelagic sedimentation in an anoxic quiet-water environment as indicated by their high organic carbon content (Fig. 6), well developed textural lamination, and absence of bioturbation.

Figure 20. Basinal facies consisting of black shale with a few thin siltstone beds. Brallier Formation, Virginia Highway 16 section, unit 32 (Section 23, Appendix 1). Mattock handle is 1 m long.

MODERN SUBMARINE FAN MODEL

Knowledge of submarine fans and deposition of turbidite sequences is mainly based on studies of modern submarine fans, and ancient flysch sequences. The submarine fans which have been most studied are those off the west coast of North America (Nelson and others, 1970; Normark, 1970; Normark and Piper, 1972). From these examples and a few others we have good descriptions of fan geometry, physiography, lithology, and facies distribution. Dispersal patterns can be inferred from these data. Several workers have attempted to integrate their observations of turbidite facies in ancient rocks with what is known about the physiography and facies distribution of modern fans (Walker and Mutti, 1973; Walker, 1978).

Because it is from the perspective of this model that we tend to look at turbidite sequences, a brief review of its salient features is germane. Much of what follows is based on the work of Nelson and Kulm (1973), Normark (1978), and Walker (1978). The data base consists mostly of many reflection profiles and shallow sediment cores.

Submarine fans are typically divided into three physiographic areas (Fig. 21): a channeled upper fan, fed by a submarine canyon; a mid fan region with many distributary channels in its upper part and smooth depositional lobes in its lower part; and a smooth lower fan area which merges distally with the basin plain. Grain size, bed thickness, sand/shale ratio, and relief all generally decrease in the down-fan direction. Similar gradients also occur laterally, away from channel axes. Bouma sequences also become more base-truncated laterally

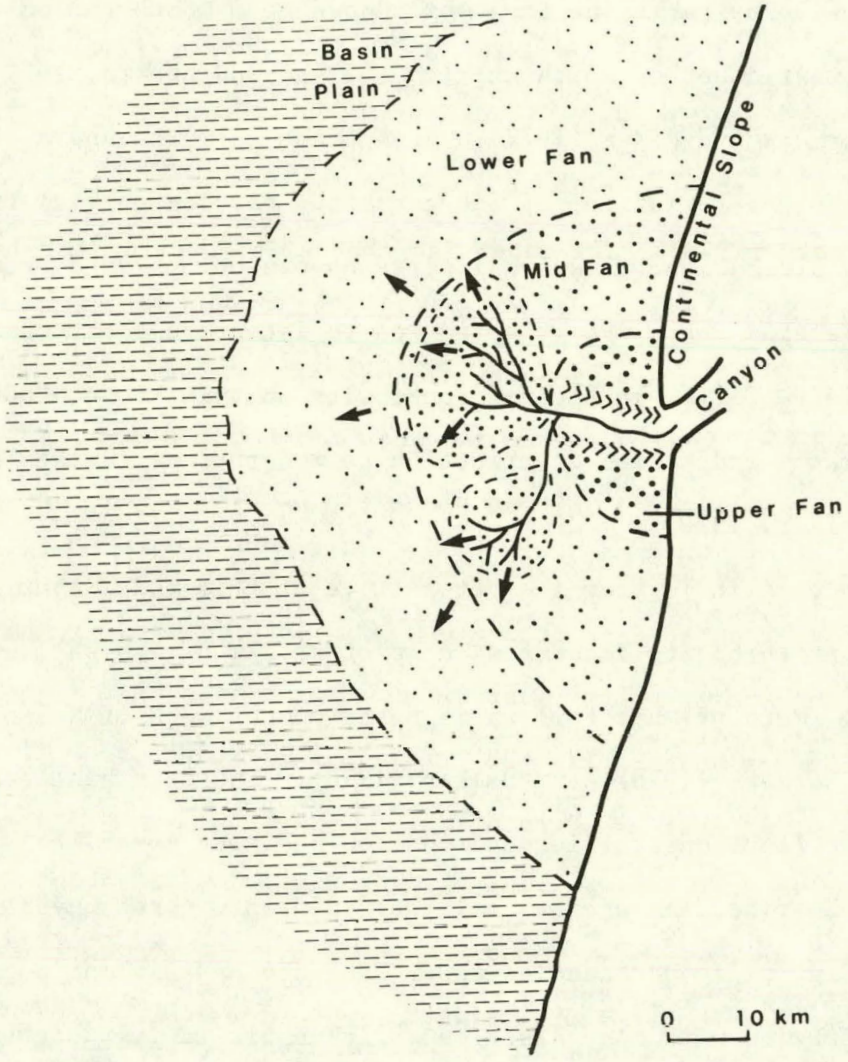

Figure 21. Physiography of a typical submarine fan. There is a general down-fan decrease in grain size and radial dispersal pattern. Modified from Normark (1978, Fig. 1).

and in the down-fan direction. The upper fan has the most rugged topography because of the extensive levee development, and remnant abandoned channels. Rapid and profound morphological changes take place in the mid fan area. Gradients flatten abruptly and the fan profile becomes convex upward, as opposed to the normal concave upward profiles of the upper and lower fan. This depositional bulge, characteristic of the lower mid fan has been called the "suprafan" by Normark (1970). The upper fan channel bifurcates into a system of sinuous distributary channels on the upper mid fan. These mid fan distributary channels lack the levee development typical of the upper fan channel. The lower fan is characterized by the lowest gradients and smoothest surface. Channels are generally absent or inconspicuous on the lower fan because of their very low relief.

The progradation of a submarine fan such as depicted in Figure 21 produces a distinctive stratigraphic sequence of facies which overall coarsens upward (Fig. 22).

The channel deposits of the submarine canyon and upper fan valley consist of the thickest, most poorly bedded, coarsest, least structured, and most poorly sorted sands and gravels. Thick beds forming lenticular bodies, disturbed bedding, slump blocks, and pebbly mudstones are typical of the submarine canyon. The upper fan channel deposits are usually massive and lack sedimentary structures typical of the Bouma sequence. Clast-supported conglomerates, debris flows, and slump deposits comprise the upper fan channel fill. Mud interbeds are typically thin, silty, and poorly developed. Minor thin fine-grained turbidites

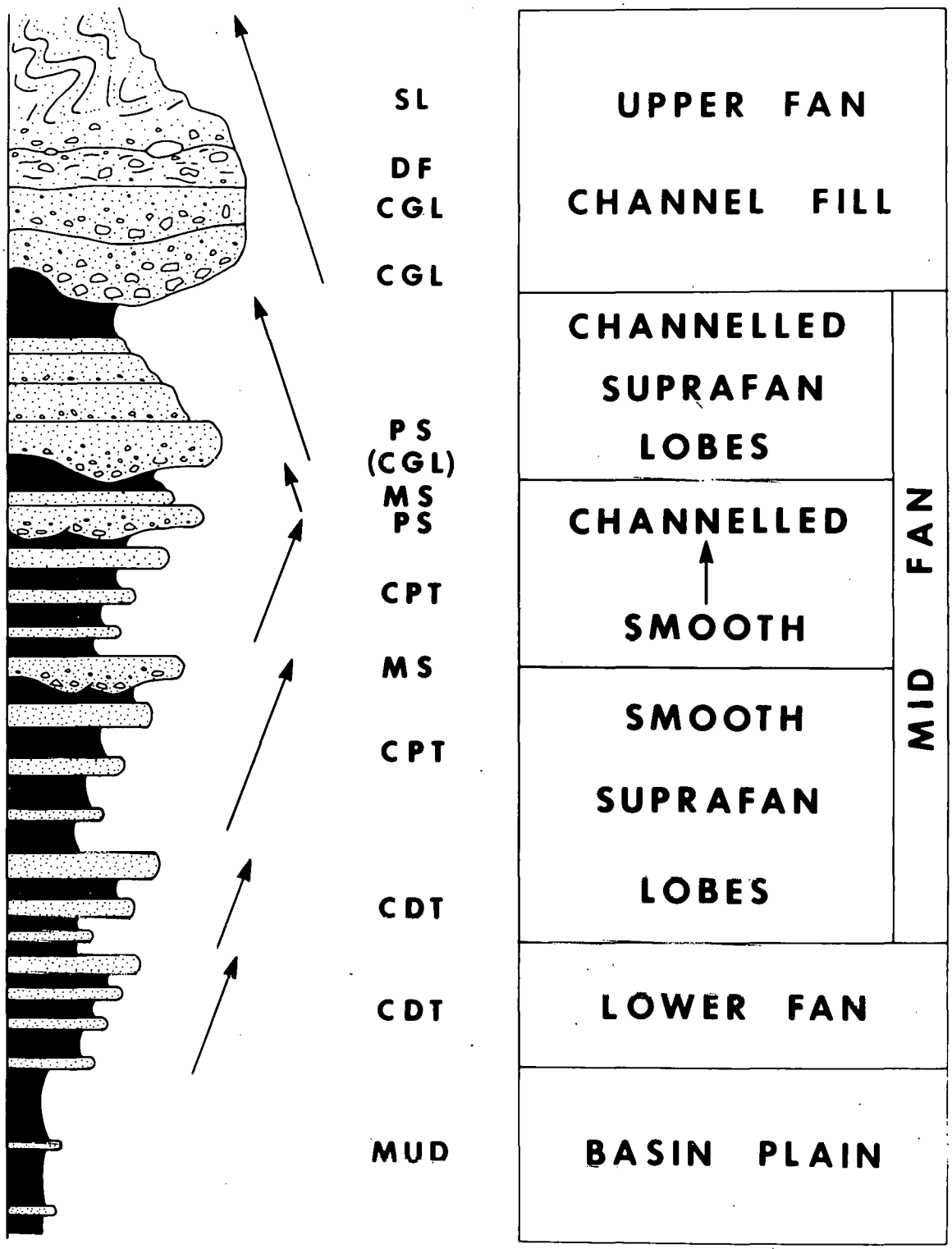

Figure 22. Schematic stratigraphic sequence produced by a prograding submarine fan. Inclined arrows indicate thickening- and coarsening-upward (inclined to the right), or thinning- and fining-upward sequences (inclined to the left); CDT, classic distal turbidites; CPT, classic proximal turbidites; MS, massive sandstones; PS, pebbly sandstones; CGL, conglomerate; DF, debris flows; and SL, slumps. Modified from Walker (1978, Fig. 14).

and mud occur on the upper fan channel levees and interchannel areas.

The channels of the mid fan contain lenticular, massive and pebbly sandstone beds and thinner, finer-grained turbidites. Sands of the mid fan valley are most likely to have the entire Bouma sequence. Laterally shifting channels produce thinning-upward megasequences on the channeled mid fan. Mid fan interchannel deposits are mud interbedded with classic "proximal" to classic "distal" turbidites. The outer, smooth portion of suprafan depositional lobes consists of classic "distal" to classic "proximal" turbidites in coarsening- and thickening-upward sequences possibly with channeled massive sandstones at their top.

The lower fan has fewer and thinner turbidites than the mid fan and their Bouma sequences are generally more base-truncated. Coarsening- and thickening-upward sequences are commonly present.

Basin plain deposits consist of mud, possibly with a few thin turbidite beds.

DEPOSITIONAL MODEL OF THE BRALLIER FORMATION

How well do the foregoing descriptions match our six facies of the Brallier Formation depositional system?

The Brallier Formation is finer grained and thinner bedded than most modern submarine fan and ancient flysch deposits (Fig. 23). Grain size in the Brallier sequence is largely in the silt to very fine sand range and siltstone and sandstone bed thickness averages less than 10 cm. The entire stratigraphic sequence from basinal shale to non-turbiditic deltaic sandstone and mudrock includes only the classic turbidite members of the resedimented coarse clastic family as described by Walker (1978) (Fig. 23). Differences also exist in the proximal facies, especially in the stratigraphic transition from turbidites to non-turbidites. In the Brallier Formation this transition is gradual and characterized by thickening-upward sequences of classic turbidites of the turbidite slope facies, and crossbedded traction deposits of the delta front facies (Fig. 23). Contrasting with this are the channeled thinning-upward sequences of massive and pebbly sandstones, conglomerates, debris flows, and slumps which characterize the proximal deposits of modern submarine fans (Fig. 22). It is evident that the Brallier depositional system was of lower flow intensity than those of most modern submarine fans and ancient flysch sequences.

The facies relationships and homogeneous transverse paleocurrent pattern indicate that the Late Devonian slope of the Appalachian basin was not fed by submarine canyons. Instead, prograding deltas probably spread sediment directly onto the slope (Fig. 24). The absence of

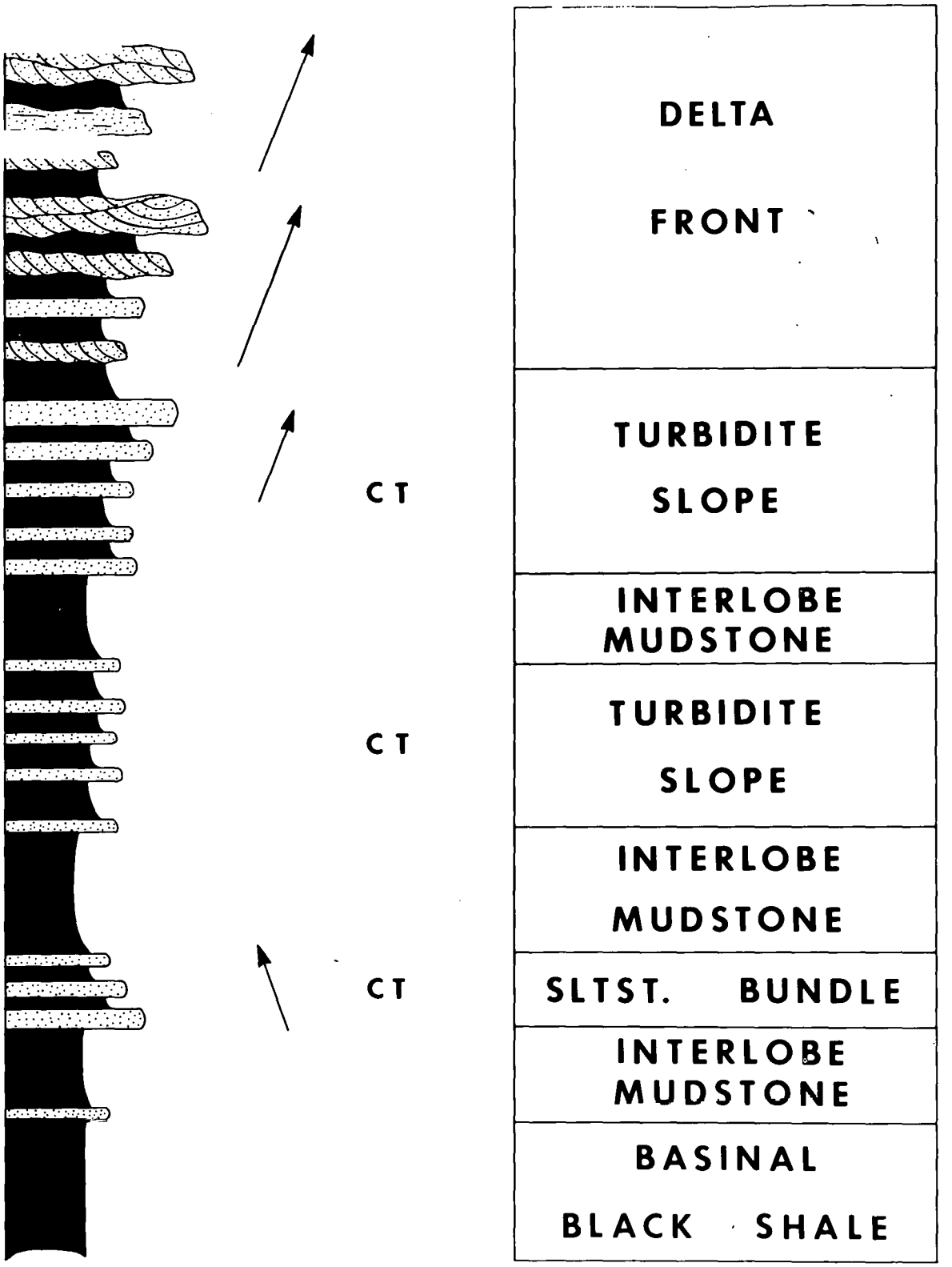

Fig. 23. Schematic representation of the Upper Devonian stratigraphic sequence in western Virginia and its facies interpretation. Inclined arrows indicate thickening- and coarsening-upward (inclined to the right), or thinning- and fining-upward sequences (inclined to the left); CT, classic turbidites. Total thickness is approximately 1000 m.

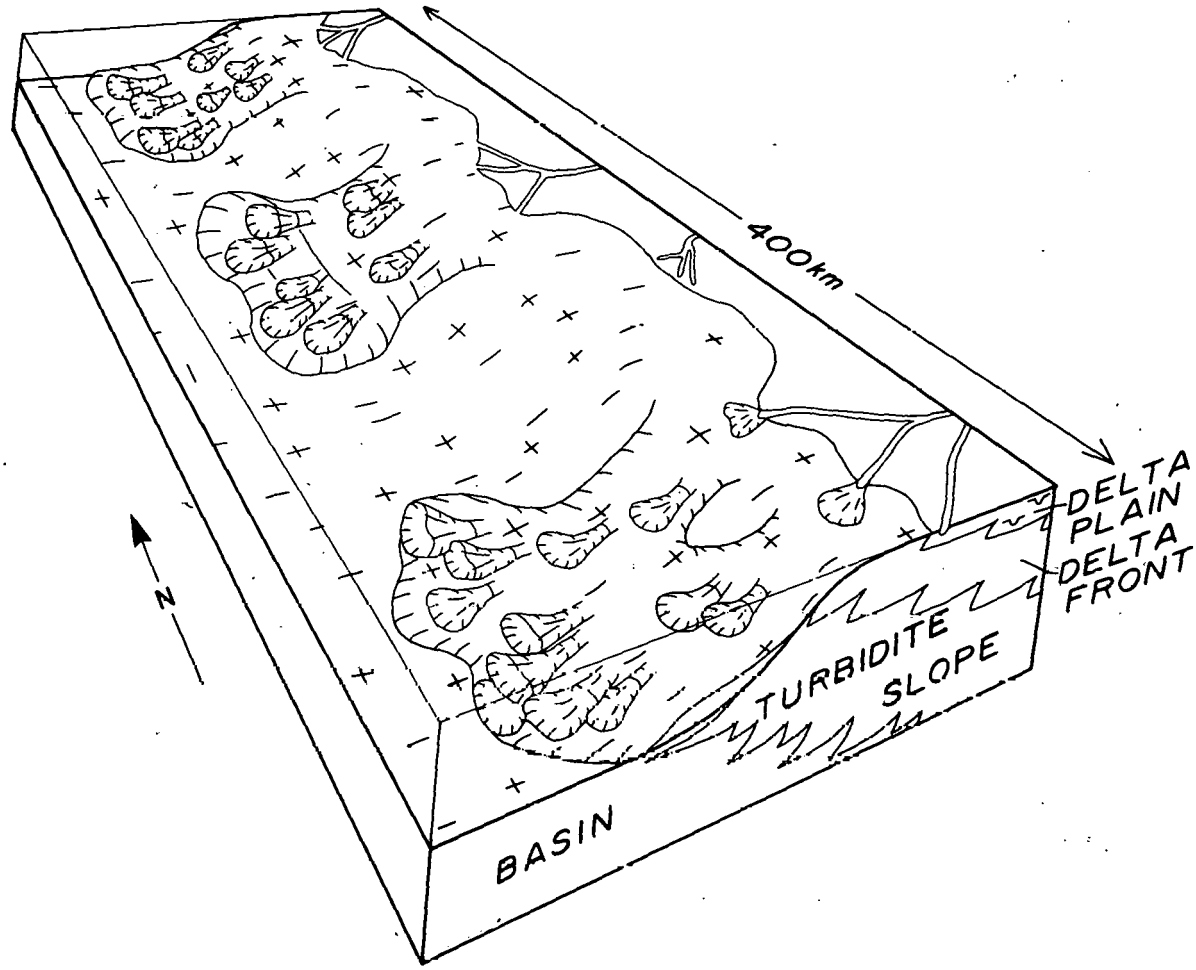

Figure 24. Interpretive reconstruction of the Late Devonian paleo-slope. Small ephermal submarine fans coalesced in time along the slope and base-of-slope.

identifiable canyon and channeled upper fan facies indicates that the slope was previously unsculptured by rivers, as some shelf margins were during the Pleistocene, or that turbidity currents were too weak or scattered in their occurrence to incise the slope. The predominance of thickening-upward sequences in the proximal facies and vagueness of megasequences elsewhere in the turbidite-slope facies suggest turbidity currents were generally unrestricted by channel walls or natural levees. The continuity and evenness of bedding in single outcrops also support this. The uniformity of paleocurrents suggests that sediment sources for turbidity currents shifted frequently. This is to be expected in deltaic environments because of the routine switching of deltas and distributaries. Major delta lobes of the Mississippi River have shifted about every 1000 years (Coleman, 1976, p. 26) and distributaries shift position even more frequently. Although turbidity current sources were not stable for long periods of time, small sediment lobes no doubt developed downslope of these sources. The small ephemeral lobes coalesced in time to form an apron of turbidites along the Late Devonian slope and base-of-slope (Fig. 24). Kepferle (1978, p. 232) described a similar system in the Mississippian Borden Formation of Kentucky and Indiana as a fan apron. Bioturbated mudstone accumulated by hemipelagic sedimentation on the slope lateral to areas of active turbidite deposition. Lower on the slope, at the margins of the turbidite lobes, hemipelagic bioturbated claystone and shale with turbidite silt laminae were deposited. The slope environment was generally dysaerobic and inhabited only by soft bodied organisms. Black shales accumulated by

hemipelagic sedimentation of mud and organic matter basinward of the turbidites in quiet, stagnant water.

The Upper Devonian paleoslope was probably very low, most likely less than 0.2 degrees. One line of evidence is the apparent absence of major slumping, so conspicuous in most turbidite sequences (Cline, 1970; McBride, 1970; Potter and Pettijohn, p. 208-214). Slumping on mud slopes as low as 0.6 degrees is very common on the Mississippi River prodelta (Shepard, 1955). Also, because the Brallier is sedimentologically similar to lower fan environments one can infer that their slopes are similar. If the paleoslope were steeper than lower fan slopes, the Brallier turbidites would show different sedimentation styles because of the increased velocity and erosive capacity of the currents. The gradients of the lower parts of modern submarine fans range from about 0.06 degrees to 0.15 degrees (Nelson and others, 1970, p. 277 and 284).

Water depth in the basin receiving the Brallier turbidites is difficult to estimate. Using Klein's (1974) stratigraphic method of estimating water depth in deltaic sequences the water could not have been more than 3200 ft. deep. This value is based on a stratigraphic thickness of 3000 ft. for the rocks between the basinal shales and the topset deltaic sandstones, and 200 ft. of water overlying these topset deposits. It is considered a maximum value, because it does not allow for penecontemporaneous subsidence. At present no better estimate is possible because marker beds have not been recognized in the Brallier Formation. For comparison, we applied Klein's model to the overlying Lower Mississippian deltaic deposits which also include turbidites.

Using the measured sections of Bartlett (1974) in southwestern Virginia and Hasson (1972) in eastern Tennessee, we estimated water depths from 460 to 690 feet. It is to be expected that water depths will be shallower during the later phase of basin filling represented by these Lower Mississippian clastics. However, the five fold difference in water depths calculated from the Upper Devonian and Lower Mississippian deltaic sequences supports the idea that subsidence contributed to our comparatively large value of 3200 ft. for Late Devonian water depth given above. The topography of the Lower Mississippian Borden delta in southern Illinois suggests that the Upper Devonian black shales in that area were deposited in at least 600 ft. of water (Lineback, 1966, p. 22). It is probable that the Late Devonian sea was shallower in cratonic areas such as Illinois than in the Appalachian basin.

The cause or initiating mechanism of the turbidity currents is unknown. Turbidity currents are commonly thought to be initiated by submarine slumping of sediments on a slope, and indeed some turbidite sequences have major slump structures in their proximal facies (Cline, 1970; McBride, 1970). However, we have observed no such features in our study area although Walker (1971) observed some slump structures in the Trimmers Rock Formation (now called Brallier) of central Pennsylvania. Where evidence for slumping is absent alternative initiating mechanisms such as storm surges and high river discharges should be considered. The relative thin and uniform thickness of turbidites in the Brallier Formation indicate that whatever mechanism responsible for triggering the turbidity currents was of uniformly low intensity.

Although turbidites were deposited along most of the slope from New York to Tennessee, near the Virginia-Tennessee border (Fig. 1, Sections 27-32) little or no coarse clastics were deposited. Only muds of the interlobe slope, lobe margin, and basinal facies accumulated. Turbidity currents occurred frequently to the north and somewhat less frequently to the south in eastern Tennessee. These features probably reflect the absence of a delta feeding silt and sand to the slope in this area. The gray silty shale unit of the middle Chattanooga Shale in eastern Tennessee, however, appears to be the manifestation of a delta farther south. It is a lens of mudshale, siltstone, and sandstone, which in part consists of turbidite siltstone beds and turbidite silt laminae in shale. The gray silty shale unit is the southernmost occurrence of Upper Devonian silt and sand in the Appalachian basin. As a whole it shows pronounced coarsening- and thickening-upward (please see Section 33, units 1-15, in Appendix) from black clayshale, to mudshale with abundant silt laminae, to turbidite siltstone beds, to thick massive sandstone beds. Distinct turbidite siltstone beds are only present at the Flat Gap section (Section 33 in Appendix), where they are 0.5 to 2.5 ft. thick, and at the U.S. Highway 25 section (Section 34 in Appendix), where one bed was observed.

In the Greendale syncline belt the gray silty shale unit is traceable for approximately 18 miles parallel to depositional strike (projected onto a north-south line), from Little War Gap in the northeast to near Joppa in the southwest. Except for the silt-laminated shale, the massive sandstones are the most extensive facies, traceable

for approximately 11 miles parallel to depositional strike and for a greater distance southwestward of their thickest occurrence than northeastward. The unit of turbidite siltstones has the least lateral continuity, probably less than 5 miles.

Based on its geometry and distribution of facies, we interpret the gray silty shale unit of the Chattanooga Shale as a turbidite lobe deposited basinward of a westward prograding delta. This delta must have been located somewhere to the east of where these turbidites now crop out, in northeastern Tennessee or northwestern North Carolina. This lobe differs from modern submarine fans in its facies distribution in most of the respects that the Brallier Formation does. Turbidite siltstone beds 0.5 to 2.5 ft. thick with T_{a-}, T_{b-}, and T_{c-} Bouma sequences were deposited along the axis of the lobe possibly in a channel. Concurrently, a few thin turbidite siltstones with T_{c-} Bouma sequences, turbidite silt laminae, and hemipelagic mud were deposited laterally to, and basinward of these turbidite beds. The massive sandstone beds which overlie the units of turbidite siltstone beds and shale with turbidite silt laminae were probably deposited by traction currents landward of the turbidity currents and then reworked by burrowing organisms.

GAS POTENTIAL

Are there gas reservoirs in the Brallier Formation? Which facies has the most potential? Where will these rocks be found in the subsurface? Our study suggests that the siltstone bundles show promise of being natural gas producers in the subsurface, especially if they

are fractured and the intergranular spaces are not completely filled by cements.

The siltstones of the siltstone bundle facies contain appreciable fine interstitial clay matrix and carbonate and silica cement, and therefore are of rather low primary reservoir quality. Local fracture porosity and permeability could greatly improve their potential. Similar "tight" siltstones in the Benson field of north-central West Virginia show moderate gas production (Cheema, 1977, p. 31-44). In the Benson field, only 20 miles west of Brallier Formation outcrops, gas is exploited from linear bundles of Upper Devonian middle to lower-slope turbidites (Cheema, 1977). These bundles are similar to siltstone bundles observed by us and are composed of siltstones with permeabilities less than 2.0 Md (Cheema, 1977, p. 40-42), suggesting significant fracture porosity and permeability. Judging from the Benson field, the turbidite bundles of the Brallier Formation are easily its most attractive potential gas reservoirs. The ubiquitous occurrence of these siltstone bundles along the outcrop in West Virginia and west-central Virginia suggests that similar reservoir units should be present in the subsurface immediately to the west in southern West Virginia. Cheema (1977, p. 29-31) and Patchen (1977, Fig. 5 and 6) showed that linear siltstone bundles in the Benson sand have high continuity into the basin. Although outcrop samples of Brallier Formation mudrocks have low organic carbon contents (Table 3), more organic-rich source beds are present farther basinward to the west.

Judging from the organic content of mudrocks in our Brallier outcrops, these rocks do not have much promise as source beds. However,

farther to the west in the deeper and more poorly oxygenated parts of the basin shales rich in organic matter are common (Patchen, 1977).

CONCLUSIONS

This study yielded thirteen conclusions which belong to three general groups - depositional environment, provenance, and gas potential:

1) The present-day turbidite facies model, based mainly on modern submarine fans and ancient flysch sequences, does not adequately describe the depositional system of the Brallier Formation.
2) The Brallier Formation turbidites are finer grained and thinner bedded than the deposits of most modern submarine fans and ancient flysch systems.
3) The entire stratigraphic sequence from basinal to topset deltaic deposits contains only the classic turbidites member of the resedimented coarse clastic family.
4) The stratigraphic transition from turbidites to the overlying deltaic traction deposit is gradual and lacks the facies characteristic of the proximal parts of modern submarine fans.
5) Turbidite paleocurrents indicate a homogeneous transverse dispersal pattern, atypical of flysch sequences, which suggests that turbidity currents had multiple sources.
6) The Brallier turbidites were deposited on a relatively smooth surface lacking major channels.

7) Turbidites were deposited on a series of small ephemeral turbidite lobes of low flow intensity which coalesced in time to form a laterally extensive wedge.

8) The turbidite lobes were fed by deltas rather than submarine canyons or upper fan channels.

9) Bioturbated olive gray mudstone accumulated by hemipelagic sedimentation on the slope, lateral to areas of active turbidite deposition.

10) Bioturbated claystone and shale with turbidite silt laminae were deposited at the margins of turbidite lobes and on the lower reaches of the slope.

11) Black shales were deposited by hemipelagic sedimentation of mud and organic matter basinward of the turbidite lobes.

12) The ultimate source for the Brallier Formation was an eastern complex of sedimentary and low-grade metasedimentary rocks.

13) The siltstone bundle facies may make good gas reservoirs in the subsurface of southern West Virginia, especially if fracture porosity is well developed.

ACKNOWLEDGMENTS

The authors wish to thank Paul Edwin Potter (Principal Investigator) and Barry Maynard of the H. N. Fisk Laboratory for their help, and Attila Kilinc, Head of the Department of Geology at the University of Cincinnati, for his support. Greg Hinterlong assisted in some of the field work. Roy C. Kepferle, U.S. Geological Survey, also contri-

buted significantly. Lily Kao ran the elemental analyses. This study was funded by the Department of Energy contract ERDA No. EY-76-C-05-520J ORD 5201-4, and we thank them for their support.

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APPENDIX

Measured Sections

Lithologic names used in the following section descriptions are those discussed in the text under the classification of mudrocks. Colors refer to those of the rock-color chart (Goddard and others, 1963). Estimates of siltstone percentage were made in the field with bar comparators and were frequently checked by bed by bed measurements. Designations such as Ta, Ta-e, and Tb- are used to describe Bouma sequences (Bouma, 1962) in siltstone beds. Subscripts refer to specific Bouma units with Ta-e describing a complete Bouma sequence and Tb- indicating only that the bed or beds begins with the Bouma b unit.

The sections (Fig. 1) range from Pennsylvania (Section 1) to Tennessee (Section 35) and appear in that order.

SECTION 1

Huntingdon Section

Incomplete section of the middle part of Brallier Formation exposed for 0.28 mile in roadcuts along north side of Penn Street at intersection with U.S. Highway 22, 0.9 mile east of Pennsylvania Highway 26. Base of section is located 1300 feet east of Standing Stone Creek on Penn Street, Huntingdon, Huntingdon County, Pennsylvania (Huntingdon and Mount Union quadrangles, 754050 East, 4484950 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, September 2, 1978.

Devonian (incomplete):	Thickness (feet)	
Brallier Formation (incomplete):	Unit	Cum.
10. Mudstone (50 percent), siltstone (30 percent) and clayshale (20 percent). Mudstone is medium dark gray (N4), weathers olive gray (5Y4/1) to small, thin chips and blades; irregular partings 3 to 5 mm thick. Clayshale is texturally laminated; weathers to blades and "pencils" 1 to 3 mm thick. Clayshale predominates in lower 25 ft of unit, becomes siltier upward. Siltstone is medium dark gray (N4) to medium gray (N5), weathers olive gray (5Y4/1) with dark yellowish orange (10YR6/6) limonitic stain; micaceous; beds range in thickness from 0.05 to 0.1 ft; planar and cross lamination common; Tbc and Tc Bouma sequences common; sharp planar bases and sharp, rippled tops...	103	594.6
9. Covered.....	91	491.6
8. Mudstone and clayshale (65 percent) and siltstone (35 percent); like unit 10.....	16.2	400.6
7. Mudstone (50 percent), siltstone (40 percent) and clayshale (10 percent). Mudstone like unit 10. Siltstone like unit 10 in beds 0.05 to 0.5 ft thick with mode of 0.2 ft; Tc Bouma sequences very common, Tbc and Ta sequences less common; content graded; organic sole markings common; minor non-bedded, non-laminated siltstone. Clayshale is olive gray (5Y3/2), weathers olive gray (5Y4/1) with moderate yellowish brown		

		Thickness (feet) Unit	Cum.
	(10YR5/4) limonitic stain, to thin chips and blades; texturally laminated; silt-free to slightly silty; hard, fissile.....	30.3	384.4
6.	Mudstone with minor clayshale (55 percent) and siltstone (45 percent). Mudstone like unit 10, bladed weathering common. Siltstone like unit 10; beds range in thickness from 0.1 ft to 1.8 ft, mode is between 0.2 and 0.4 ft; Tabce and Tbce Bouma sequences common; beds generally even and continuous, however, beds less than 0.1 ft thick commonly pinch and swell; beds often massive and blocky.....	60.8	354.1
5.	Interlaminated mudstone and non-bedded siltstone (60 percent), bedded siltstone (30 percent) and clayshale (10 percent). Mudstone and siltstone interlaminated on scale of 1 cm; mudstone like unit 10; siltstone is medium gray (N5) to olive gray (5Y4/1); indistinctly bedded; planar and cross lamination common. Bedded siltstone is medium dark gray (N4) to medium gray (N5), weathers olive gray (5Y4/1); micaceous; beds range in thickness from 0.05 to 0.5 ft, mode is 0.1 ft; slight lateral thickness variation common; Tac Bouma sequences common; pinch and swell common; soft sediment deformation (flow rolls) present. Clayshale like unit 7.....	53.5	293.3
4.	Siltstone (70 percent), mudstone (20 percent) and clayshale (10 percent). Siltstone is medium gray (N5), weathers olive gray (5Y4/1) with dark yellowish orange (10YR6/6) limonitic stain; beds range in thickness from 0.05 ft to 2.8 ft, mean is 0.7 ft and mode is between 0.2 to 0.4 ft, amalgamation of beds common; planar and ripple lamination common; types 1 and 3 climbing ripple lamination in drift (Walker, 1963) common in few beds; massive and structureless beds also common; organic sole markings common; load casts present; carbonized wood fragments very abundant on some bedding planes (with average orientation of 259°) and are often		

		Thickness (feet) Unit	Cum.
	concentrated in linear bodies 0.3 ft wide separated by about 0.5 ft swath of low concentration; content grading common; partings 2 to 3 mm thick in upper 1 cm of many beds. Mudstone is medium dark gray (N4), weathers olive gray (5Y4/1); irregular partings 3 to 4 mm thick; hackly weathering surface. Clayshale more common in upper half of unit; moderate olive brown (5Y4/4) to medium dark gray (N4); weathers olive gray (5Y4/1) to blades and chips; texturally laminated; silt-free; parallel partings 2 mm thick; hard, fissile; usually occurs in gradational contact with underlying siltstone beds. Beds strike 225° dip 15° SE.....	112.2	239.8
3.	Siltstone (60 percent), mudstone (35 percent) and clayshale (5 percent). Siltstone is medium dark gray (N4) to medium gray (N5), weathers olive gray (5Y4/1) with dark yellowish brown (10YR4/2) and moderate yellowish brown (10YR5/4) limonitic stain; micaceous; beds range in thickness from 0.1 ft to 1.1 ft, mode is between 0.4 to 0.5 ft; cross lamination common in beds less than 0.2 ft; Tc Bouma sequences most common, Tac and Tabc sequences common in thicker beds; current formed sole markings include groove casts oriented 275° and 280°; organic sole markings also common. Mudstone like unit 4. Clayshale like unit 4.....	40.9	127.6
2.	Interbedded siltstone and mudstone in unequal amounts (65 percent), bedded siltstone (30 percent) and clayshale (5 percent). Siltstone (70 percent) and mudstone (30 percent) interbedded on scale of 1 to 3 cm; siltstone indistinctly bedded; planar and cross lamination common; mudstone weathers medium gray (N4) to olive gray (5Y4/1) to small blades; rare silt laminae less than 1 mm thick. Bedded siltstone like unit 3; beds generally less than 0.25 ft with few beds 0.6 to 0.7 ft and maximum of 1.3 ft thick. Clayshale is olive gray (5Y4/1); texturally laminated;		

		Thickness (feet) Unit	Cum.
	silt-free; regular parallel partings 1 to 2 mm thick. Two 0.4 ft thick highly burrowed zones form slight recesses on outcrop.....	35.7	86.7
1.	Siltstone (70 percent), mudstone (25 percent) and clayshale (5 percent) with mudshale in lower 5 feet of unit. Siltstone is medium dark gray (N4) to olive gray (5Y4/1), weathers olive gray (5Y4/1) with dusky yellowish brown (10YR2/2) limonitic stain; micaceous; beds range in thickness from 0.1 ft to 3.9 ft; mode is between 0.1 and 0.3 ft, mean is 0.7 ft; amalgamation of beds common; Tabc, Tab and Ta Bouma sequences common, Tc sequences less common; current-formed sole markings include flute mark oriented 295° with blunt end toward east and numerous fine grooves with general orientation of 295°; sharp, planar bases and sharp, rippled tops; blocky. Mudstone is olive gray (5Y4/1) weathers olive gray (5Y4/1); hackly irregular partings 3 to 7 mm thick. Clayshale is moderate olive brown (5Y4/4), weathers olive gray (5Y4/1); texturally laminated; silt-free; fissile, soft; regular parallel partings 1 to 2 mm thick. Beds strike 236°, dip 25° SE.....	51.0	51
	Total Brallier Formation (incomplete)...	594.6	

SECTION 2

Cypher Section

Incomplete section of lower Brallier Formation exposed for 0.4 mile along the north side of Pipers Run Road. Base of section located 100 yards east of intersection of Pipers Run Road and north-trending road, 0.5 mile west of Cypher, Bedford County, Pennsylvania (Everett East quadrangle, 728740 East, 4441654 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, September 5, 1978.

	Thickness (feet) Unit	Cum.
Devonian (incomplete):		
Brallier Formation (incomplete):		
12. Clayshale (60 percent), and siltstone and very-fine-grained sandstone (40 percent). Clayshale is moderate olive brown (5Y4/4), weathers olive gray (5Y4/1) to small chips; texturally laminated; silt-free; fissile, brittle; papery partings 1 mm thick or less. Siltstone and sandstone are olive gray (5Y4/1), weather olive gray (5Y4/1) with dark yellowish brown (10YR4/2) to moderate brown (5YR3/4) limonitic stain; beds less than 0.5 ft thick, mode is less than 0.1 ft; cross lamination common; Tac and Tc Bouma sequences common; sharp, planar bases and gradational, rippled tops; platy partings 3 to 5 mm thick common; very-fine-grained sandstone bed at 60.7 ft below top of unit is 2.0 ft thick and contains rare clay galls.	104.1	840.7
11. Sandstone, olive gray (5Y4/1) with limonitic stain; micaceous; blocky; may be amalgamation of 5 or 6 beds; shaley partings 0.3 to 0.4 ft apart; Ta Bouma sequence; sole markings absent.....	2.2	736.6
10. Clayshale (60 percent) and siltstone (40 percent), like unit 12.....	19.4	734.4
9. Covered (probably like unit 10).....	45.0	715.0
8. Clayshale (60 percent) and siltstone (40 percent) like unit 12. 5 ft thick deformed zone between 47 and 52 feet above base.....	214.0	670.0
7. Mudshale with minor clayshale (65 percent) and siltstone (35 percent). Mudshale is moderate olive brown (5Y4/4), weathers olive gray (5Y4/1) with limonitic stain; texturally laminated; show both disseminated silt and thin, parallel silt laminae less than 1 mm thick; hard, brittle; partings 2 to 4 mm thick. Clayshale like mudshale except silt-free. Siltstone is light olive gray (5Y6/1) to olive gray (5Y5/2), weathers to blades of light olive gray (5Y5/2) with dark		

		Thickness (feet) Unit	Cum.
	yellowish brown (10YR4/2) to moderate brown (5YR3/4) limonitic stain; micaceous; beds less than 0.2 ft thick; cross lamination common; Tc Bouma sequences; sharp, planar bases and rippled tops give pinch and swell effect; organic sole markings common, current-formed sole markings absent; partings 2 to 4 mm thick.....	110.0	456.0
6.	Covered (probably like unit 7).....	122.0	346.0
5.	Mudshale (65 percent) and siltstone (35 percent), like unit 7.....	53.0	224.0
4.	Covered.....	29.0	171.0
3.	Mudshale (65 percent) and siltstone (35 percent). Mudshale like unit 7. Siltstone like unit 7 in color, beds generally massive and structureless; Ta Bouma sequences most common, Tab and Tabc sequences also present.	2.3	142.0
2.	Covered.....	114.2	139.7
1.	Mudshale (65 percent) and siltstone (35 percent). Mudshale like unit 7. Siltstone like unit 7 in 10 beds which range from 0.2 ft to 3.4 ft thick with mean of 0.9 ft; Ta, Tab and Tabc Bouma sequences; partings 3 to 5 mm thick common in upper 1 or 2 cm of beds.....	25.2	25.2
	Total Brallier Formation (incomplete)..	840.7	

SECTION 3

Type Section

Only the lowermost Brallier Formation is described from this exposure in cuts along the abandoned Huntingdon and Broad Top Mountain Railroad approximately 1 mile northeast of Tatesville, in Bedford County, Pennsylvania (Everett East quadrangle). Underlying the Brallier Formation here and exposed but not described at this section

are the Harrell Shale (175 ft) and the Tully Limestone (1 ft). Top of section located at eastern end of railroad cut near a small pond (726800 East, 4437800 North, Universal Transverse Mercator grid). Turley (1952) described approximately 40 feet of predominantly siltstone which he informally named the Shawnee Park Siltstone member from the same stratigraphic position at exposures about 15 miles to the west.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
1. Siltstone (80 percent) and clayshale (20 percent). Siltstone is medium gray (N5) weathers light olive gray (5Y5/2); beds range in thickness from 0.1 ft to 4.5 ft, mode is between 0.2 and 0.4 ft, mean is 0.7 ft; planar and cross lamination common, Ta Bouma sequences common, Tb and Tc sequences present in thinner beds; organic and current formed sole markings common include groove casts oriented 265°; 232°; 265° and flute casts oriented 330° and 340° with blunt ends toward southeast; sharp, planar bases and sharp, undulatory tops; blocky, highly fractured. Clayshale is olive black (5Y2/1) to olive gray (5Y4/1); texturally laminated; silt-free; parallel partings 1 to 2 mm thick..	84.0	84.0
Total Brallier Formation (incomplete)....	84.0	

SECTION 4

Point Section

Incomplete section of Upper Devonian including lowermost Foreknobs Formation, Scherr Formation, and all but the lowermost Brallier Formation exposed for approximately 1.0 mile in roadcuts along north side of road from Napier Church (1.5 miles north of U.S. Highway 30) to town of Point. Base of section located immediately east of highway marker (1/70) approximately 800 ft east of intersection in Point, Bedford County, Pennsylvania (Bedford quadrangle; 704680 East, 4438750 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, September 8-10, 1978.

		Thickness (feet)	
Devonian (incomplete):			
Foreknobs Formation (incomplete):		Unit	Cum.
45.	Sandstone (80 percent) and clayshale (20 percent). Very-fine-grained sandstone is olive gray (5Y4/1) to brownish gray (5YR4/1), weathers with limonitic stain; beds range in thickness from 0.05 ft to 2.1 ft, rapid lateral thickness variations; cross lamination rare; soft-sediment deformation rare; sharp, undulatory bases and tops; subparallel partings 3 cm thick; rare fossils include Atrypa sp. Clayshale is moderate olive brown (5Y4/4) to light olive brown (5Y5/6); texturally laminated; silt-free, partings 1 to 2 mm thick.....	50.0	2695.6
44.	Mudshale (60 percent), siltstone and very-fine-grained sandstone (20 percent) and clayshale (20 percent). Mudshale is moderate olive brown (5Y4/4) to brownish gray (5YR4/1); texturally laminated; irregular partings 2 to 4 mm thick. Siltstone and sandstone like unit 45 in beds less than 0.25 ft thick; cross lamination common; sharp, undulatory bases and sharp tops; rare fossils include Atrypa sp. Clayshale like unit 45.....	14.0	2645.6
43.	Covered.....	31.0	2631.6
42.	Mudshale (60 percent) and sandstone (40 percent). Mudshale weathers light olive brown (5Y5/6); texturally laminated; very silty; partings 2 to 3 mm thick. Sandstone is very-fine- to fine-grained; dark yellowish brown (10YR4/2), weathers with limonitic stain; beds range in thickness from 0.05 ft to 1.0 ft, often lenticular with rapid lateral thickness variations, amalgamation of beds common; sharp bases and sharp, undulatory tops; fossiliferous, including Atrypa sp., Spirifer sp., pelmatazoon debris, pelecypods and rare bryozoan.....	25.0	2600.6
41.	Mudshale and mudstone (50 percent increasing downward to 65 percent) and sandstone (50 percent decreasing downward to 35 percent). Like unit 42.....	55.0	2575.6

		Thickness (feet) Unit	Cum.
40.	Sandstone (80 percent) and mudshale (20 percent). Like unit 41.....	7.0	2520.6
	Total Foreknobs Formation (incomplete)....	182.0	

Scherr Formation (complete):

39.	Siltstone and clayshale in deformed zone. Siltstone is light olive gray (5Y5/2) to olive gray (5Y4/1), weathers olive gray with moderate brown (5YR4/4) limonitic stain; beds highly contorted, bending and abrupt termination of beds common. Clayshale is light olive gray (5Y5/2), weathers to small chips; texturally laminated; rare silt laminae less than 1 mm thick; partings 1 to 2 mm thick; contorted.....	20.0	2513.6
38.	Covered.....	70.0	2493.6
37.	Clayshale (70 percent increases downward to 90 percent) and siltstone (30 percent decreases downward to 10 percent). Clayshale like unit 39, but not contorted. Siltstone color like unit 39; beds range in thickness from 0.05 ft to 0.4 ft, become thinner downward, mode is less than 0.1 ft; cross lamination very common; Tce Bouma sequences common, Ta and Tb sequences common in thicker beds; sharp, planar bases and gradational, rippled upper surfaces; organic sole markings common; partings up to 2 cm thick. Beds strike 210°, dip 24° SE.....	60.0	2423.6
36.	Covered.....	70.0	2363.6
35.	Siltstone (30 percent increases downward to 60 percent) and clayshale (70 percent decreases downward to 40 percent). Siltstone like unit 39 in color; micaceous; beds range in thickness from 0.05 ft to 0.7 ft, mode is 0.1 ft; cross lamination common; Tc Bouma sequences common, Tabc sequences rare; organic sole markings common. Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2) to small chips;		

		Thickness (feet) Unit	Cum.
	texturally laminated; partings 1 to 3 mm thick.....	59.0	2293.6
34.	Covered.....	38.0	2234.6
33.	Siltstone (60 percent) and clayshale (40 percent). Siltstone like unit 35 in beds up to 1.1 ft thick; Tabc Bouma sequences common, Tc sequences common in thinner beds; current-formed sole markings include fine groove casts oriented 271°, 274°, 260°, and 300°; platy partings 1 to 3 cm thick. Clayshale like unit 35.....	76.5	2196.6
32.	Covered.....	223.5	2120.1
31.	Clayshale (70 percent) and siltstone (30 percent). Clayshale is light olive gray (5Y5/2) becomes moderate olive brown (5Y4/4) in lower half of unit, weathers light olive gray (5Y5/2); texturally laminated; silt-free to slightly silty; rare silt laminae less than 1 mm thick. Siltstone is olive gray (5Y4/1), weathers with moderate yellowish brown (10YR4/4) limonitic stain; bed thickness increases downward, mode is between 0.1 and 0.2 ft; Tace, Tbc, and Tce Bouma sequences common; organic sole markings common; base of unit marked by 0.9 ft thick bed.....	48.0	1896.6
30.	Mudshale (95 percent) and siltstone (5 percent). Mudshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2) to small, thin chips; texturally laminated; rare horizontal burrows less than 3 mm across. Siltstone like unit 31 in beds less than 0.2 ft thick.....	13.5	1848.6
29.	Mudshale with minor clayshale (60 percent), and siltstone and very-fine-grained sandstone (40 percent). Mudshale like unit 30. Sandstone is olive gray (5Y4/1) to olive black (5Y2/1), weathers olive gray (5Y6/1); beds range in thickness from 0.05 ft to 1.8 ft, mode is between 0.2 and 0.3 ft; slight		

		Thickness (feet) Unit	Cum.
	lateral thickness changes; Tac, Tabc, and Tc Bouma sequences common; fossils common in few beds, Chonetes sp. and Ambocoelia umbonata; sharp, planar bases and gradational tops; organic sole markings very common, generally slightly curved, non-branching forms 3 to 4 mm across; hard, brittle. Siltstone like unit 31.....	68.5	1835.1
	Total Scherr Formation (complete).....	678.5	
Brallier Formation (incomplete):			
28.	Mudshale (85 percent) and siltstone (15 percent). Mudshale is light olive gray (5Y5/2) to moderate olive brown (5Y4/4); compositionally laminated with silt laminae less than 0.5 mm thick common. Siltstone is olive gray (5Y4/1) in beds less than 0.2 ft thick, mode is less than 0.1 ft; Tc Bouma sequences very common.....	50.0	1766.6
27.	Covered.....	190.0	1716.6
26.	Clayshale (40 percent), mudstone (30 percent) and siltstone (30 percent). Clayshale like unit 31. Mudstone is light olive gray (5Y5/2) to moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2) to small blocks (few cm) and chips; very silty; micaceous; indistinct horizontal burrows common; very irregular partings 5 mm thick. Siltstone like unit 31 in beds 0.05 to 0.8 ft thick, mode is 0.1 ft; increases in thickness and abundance downward.....	177.0	1526.6
25.	Covered.....	91.0	1349.6
24.	"Burns Creek Siltstone Member" of Turley (1952). Siltstone and very-fine-grained sandstone (80 percent, decreases downward to 60 percent) and mudstone with minor mudshale (20 percent increases downward to 40 percent). Siltstone and sandstone like unit 31 in color; beds range in thickness from 0.05 ft to 2.0 ft, mode is 0.2 ft; some amalgamation of beds; planar and cross lamination common; Tab, Tabc, and Tac Bouma sequences most common, Tc		

		Thickness (feet) Unit	Cum.
	sequence common in thinner beds; organic sole markings common; blocky. Mudstone is moderate olive brown (5Y4/4) to olive gray (5Y4/1), weathers olive gray (5Y4/1); very silty; very irregular partings 3 to 5 mm thick.....	59.0	1258.6
23.	Mudstone like unit 24.....	6.0	1199.6
22.	Covered.....	9.0	1193.6
21.	Mudstone (95 percent) and siltstone (5 percent). Mudstone like unit 24 but less silty. Siltstone consists of one bed 0.2 ft thick plus few beds 1 cm thick or less.....	6.0	1184.6
20.	Clayshale (65 percent), and siltstone and very-fine-grained sandstone (35 percent). Clayshale like unit 31; texturally laminated; fissile; partings 1 to 2 mm thick. Siltstone and sandstone are light olive gray (5Y5/2) to olive gray (5Y4/1), weather olive gray (5Y4/1) with moderate yellowish brown (10YR5/4) limonitic stain; beds range in thickness from 0.05 to 0.3 ft, mode is between 0.05 and 0.1 ft; base truncated Bouma sequences, Tce most common, Tac and Tbc also common; planar bases and gradational rippled tops; organic sole markings common.....	46.8	1178.6
19.	Clayshale and non-laminated siltstone interbedded in subequal amounts. Siltstone is light olive gray (5Y5/2) to olive gray (5Y4/1) weathers olive gray (5Y4/1); indistinctly bedded; cross lamination rare; very irregular partings 4 to 6 mm thick; rare distinctly bedded siltstones less than 0.1 ft thick. Clayshale is moderate olive brown (5Y4/1), weathers light olive gray (5Y5/2) to small chips; texturally laminated; silt-free to slightly silty; partings 1 to 2 mm thick.....	29.8	1131.8
18.	Clayshale (95 percent) and siltstone (5 percent). Clayshale like unit 30 in color with pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6) limonitic stain; texturally laminated; silt-free; weathered partings 1-2 mm thick, fresher partings		

		Thickness (feet) Unit	Cum.
	4-5 mm. Siltstone in beds less than 0.05 ft thick; cross lamination common; Tc sequences very common; non-laminated siltstones rare..	10.0	1102.0
17.	Clayshale, poorly exposed, like unit 18.....	30.0	1092.0
16.	Clayshale like unit 18.....	25.0	1062.0
15.	Covered.....	115.0	1037.0
14.	Clayshale (90 percent) and siltstone (10 percent). Clayshale like unit 19; rare silt laminae less than 1 mm thick. Siltstone like unit 20 in beds less than 0.15 ft thick; Tbc and Tc Bouma sequences common.....	135.0	922.0
13.	Clayshale (50 percent increases downward to 70 percent) and siltstone and very-fine-grained sandstone (50 percent decreases downward to 30 percent). Clayshale is moderate olive brown (5Y4/4) in upper half of unit, becomes predominantly olive gray (5Y4/1) with minor moderate olive brown (5Y4/4) interbeds in lower half, weathers light olive gray (5Y5/2); texturally laminated; fissile, soft; parallel partings 1 to 2 mm. Siltstone and sandstone like unit 20 in color, in beds up to 0.3 ft thick, mode is between 0.05 and 0.1 ft; Tc Bouma sequences most common; rippled upper surfaces.....	78.0	787.0
12.	Covered.....	12.0	709.0
11.	Clayshale (85 percent) and siltstone (15 percent). Clayshale is olive gray (5Y4/1) weathers olive gray (5Y4/1) to light olive gray (5Y5/2 and 5Y6/1) to small chips; texturally laminated; silt-free; parallel partings 1 mm thick. Siltstone like unit 20 in color with moderate brown (5YR4/4) limonitic stain common; beds less than 0.2 ft thick, mode is approximately 0.05 ft; cross lamination very common; Tc Bouma sequences..	19.0	697.0

		Thickness (feet) Unit	Cum.
10.	Clayshale (65 percent) and siltstone and very-fine-grained sandstone (35 percent). Clayshale like unit 11. Siltstone and sandstone like unit 20 in color; beds generally less than 0.4 ft thick, mode is less than 0.1 ft; Tc Bouma sequence most common; one 0.7 ft sandstone bed shows Tbc Bouma sequence and groove casts oriented 275°, 275°, 280°, and 284°.....	11.2	678.0
9.	Clayshale (85 percent) and siltstone (15 percent) like unit 11; minor, highly burrowed claystone in beds less than 0.05 ft thick.....	25.4	666.8
8.	Clayshale (70 percent) and siltstone (30 percent) like unit 11.....	10.4	641.4
7.	Clayshale (85 percent) and siltstone and very-fine-grained sandstone (15 percent). Clayshale like unit 11. Siltstone like unit 11; one 0.9 ft thick sandstone bed at 44 ft below top shows Tbc Bouma sequence.	145.0	631.0
6.	Covered.....	110.0	486.0
5.	Clayshale (70 percent) and siltstone (30 percent). Clayshale like unit 31; silt-free; partings 1 to 3 mm thick. Siltstone is light olive gray (5Y5/2) fresh and weathered; beds generally less than 0.15 ft thick; Tce Bouma sequences common; content graded; partings 1 cm thick.....	20.0	376.0
4.	Covered.....	63.0	356.0
3.	Clayshale (70 percent) and siltstone (30 percent) like unit 5.....	5.0	293.0
2.	Covered.....	63.0	288.0
1.	Mudshale and clayshale interbedded in subequal amounts (95 percent) and siltstone (5 percent). Shales are light olive gray (5Y5/2) to moderate olive brown (5Y4/4), weather light olive gray (5Y5/2); texturally		

	Thickness (feet) Unit	Cum.
laminated; slightly silty; micaceous; irregular sub-parallel partings 2 to 4 mm thick. Siltstone is medium dark gray (N4) to light olive gray (5Y5/2) in both even and continuous beds and as non-bedded, non-laminated "beds" up to 0.2 ft thick; mode is less than 0.05 ft; cross lamination very common; pinch and swell present, sharp planar bases usually with organic sole markings; few beds, especially in lower 50 ft are calcareous with rare pelmatozoan fragments.....	225.0	225.0
Total Brallier Formation (incomplete)..	1835.1	
Total Upper Devonian (incomplete).....	2695.6	

SECTION 5

Short Gap Section

Incomplete section of Upper Devonian including Harrell Shale and lower half of Brallier Formation exposed for approximately 1.0 mile in roadcuts along West Virginia Highway 28 approximately 0.5 mile east of town of Short Gap. Base of section is located at base of undeformed black shale behind West Virginia Department of Highways building on north side of Highway 28, Mineral County, West Virginia (Cresaptown, Maryland Quadrangle, 688800 East, 6437826 North, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, April 25 to May 1, 1978 and radioactivity survey made using scintillometer by Neil Samuels and Paul Lundegard, June 10, 1978.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
35. Clayshale (65 percent) and siltstone (35 percent). Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; silt-free; subconchoidal partings 1 to 5 mm thick. Siltstone is medium gray (N5) to olive gray (5Y4/1), weathers light olive gray (5Y5/2);		

		Thickness (feet) Unit	Cum.
	beds up to 0.35 ft thick; cross lamination common; Tc Bouma sequences common; organic sole markings common; sharp planar bases and gradational rippled tops.....	6.0	1405.4
34.	Covered.....	12.0	1399.4
33.	Clayshale (90 percent) and siltstone (10 percent). Clayshale like unit 35. Siltstone like unit 35 in beds less than 0.1 ft thick.....	43.0	1387.4
32.	Clayshale like unit 35; less than 5 percent siltstone like unit 33.....	12.0	1344.4
31.	Clayshale (90 percent) and siltstone (10 percent). Like unit 33; percent siltstone increases downward to 15 percent.....	10.0	1332.4
30.	Siltstone (80 percent) and clayshale (20 percent). Siltstone is medium gray (N5) to olive gray (5Y4/1) with light brown (5YR5/6) to dark yellowish brown (10YR6/6) limonitic stain; "packet", composed of approximately 50 beds that range in thickness from 0.05 ft to 3.1 ft, mode is less than 0.2 ft with 8 to 10 beds 0.5 ft or thicker; amalgamation of beds common; Tbc and Tc Bouma sequences very common, Ta and Tac sequences less common; current formed sole markings include groove casts oriented 248°, 276°, 280°, 282°, 285°, 290°, and 294°; upper surfaces commonly covered with linguoid current ripples; carbonized woody material common along some bedding planes and also disseminated; parting thickness variable from 1 cm to 2 mm and generally decreases upward in bed; soft sediment deformation present. Clayshale is moderate olive brown (5Y4/4) to olive gray (5Y4/1), weathers light olive gray (5Y5/2); texturally laminated; silt-free to slightly silty in thin silt laminae 1 to 2 mm thick; fissile, partings 1 to 3 mm thick.....	17.2	1322.4

		Thickness (feet) Unit	Cum.
29.	Clayshale with less than 5 percent interlaminated siltstone. Clayshale is texturally laminated; silt-free; soft, fissile, papery partings 1 to 2 mm thick. Siltstone in distinct beds less than 1 cm thick.....	7.8	1305.2
28.	Siltstone (65 percent) and clayshale (35 percent). Siltstone like unit 30 in color in 9 beds that range in thickness from 0.1 to 0.35 ft thick; Tcd and Tde Bouma sequences common; current formed sole markings include groove casts oriented 279°, 281°, 285°, and 296°. Clayshale like unit 30.....	2.0	1297.4
27.	Clayshale with minor mudshale (95 percent) and siltstone (5 percent). Clayshale is moderate olive brown (5Y4/4); like unit 29. Siltstone is medium gray (N5); decreases in abundance downward; beds up to 0.25 ft thick, mode is less than 0.05 ft; lower one third of unit poorly exposed. Minor faults of unknown displacement present in unit make thickness measurement approximate.	125.5	1295.4
26.	Siltstone (85 percent) and clayshale and claystone (15 percent) exposed in fold. Siltstone is medium gray (N5) weathers light olive gray (5Y5/2); limonitic stain common; nine highly fractured, prominent beds 0.2 ft to 2.0 ft thick, few thin beds less than 0.1 ft; Tb and Tbc Bouma sequences common; upper surfaces commonly covered with linguoid current ripples; current-formed sole markings include groove casts oriented 298°, 298°, and 304°; parting thickness variable from 2 mm to 1 cm. Claystone is yellowish gray (5Y8/1); silt-free; partings 1 to 3 mm thick; abundant indistinct, horizontal burrows; forms recess on outcrop. Clayshale like unit 29.....	8.5	1169.9
25.	Clayshale with minor claystone and mudstone (70 percent increases downward to 90 percent) and siltstone (30 percent decreases		

		Thickness (feet) Unit	Cum.
	downward to 10 percent). Clayshale like unit 26, weathers light olive gray (5Y5/2); less than 5 percent mudstone and thin zones of highly burrowed, yellowish gray (5Y5/1) claystone like unit 26. Siltstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); beds range in thickness from 0.05 to 0.2 ft; Tc Bouma sequences very common.....	38.0	1161.4
24.	Clayshale (65 percent) and siltstone (35 percent). Like unit 25; siltstone in beds up to 0.7 ft thick.....	4.0	1123.4
23.	Clayshale with minor burrowed claystone and mudshale (90 percent) and siltstone (10 percent). Like unit 25; lower part of unit exposed in folded zone behind garage.....	109.0	1119.4
22.	Covered.....	53.0	1010.4
21.	Clayshale (60 percent), mudshale (15 percent) and siltstone (25 percent). Clayshale is moderate olive brown (5Y4/4) weathers light olive gray (5Y5/2); texturally laminated; silt-free; soft, fissile, papery partings 1 mm thick. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); texturally laminated; irregular, sub-parallel partings 2 to 5 mm thick. Very minor yellowish gray (5Y8/1) burrowed claystone. Siltstone is medium gray (N5) to olive gray (5Y4/1), weathers light olive gray (5Y5/2) with limonitic stain; beds range in thickness from less than 0.05 ft to 0.35 ft, mode is less than 0.05 ft; Tc Bouma sequences very common; upper surfaces commonly rippled giving pinch and swell effect to thinner beds; common organic and current formed sole markings include groove casts at 85 and 82 ft below top oriented 244°, 274°, and 286°; partings 2 to 5 mm thick.....	215.0	957.4

NOTE: Deformed zone. Unit 21 repeated by faulting and folding.

		Thickness (feet) Unit	Cum.
20.	Section continues approximately 100 yards west. Like unit 21.....	90.0	742.4
19.	Clayshale (85 percent) and siltstone (15 percent). Clayshale is moderate olive brown (5Y4/4); texturally laminated; silt-free to slightly silty; fissile, partings 1 to 2 mm thick. Siltstone like unit 21.....	45.0	652.4
18.	Covered.....	43.0	607.4
17.	Mudshale grading downward into clayshale (75 percent) and siltstone (25 percent). Clayshale like unit 21 with mudshale in upper 9.2 feet of unit. Siltstone like unit 21; beds range in thickness from 0.05 to 0.5 ft, mode is less than 0.1 ft; siltstone increases in abundance to 50 percent at 10 feet below top then decreases downward; Tb and Tc Bouma sequences common..	29.2	564.4
16.	Siltstone (80 percent) and clayshale (20 percent). Siltstone like unit 21 in color; 8 to 10 beds less than 0.1 ft thick plus beds of 0.9 ft, 0.8 ft, and 1.9 ft thick; Tbcde, Tb and Tc Bouma sequences common; partings 2 mm to 1 cm thick. Clayshale like unit 21.....	5.9	535.2
15.	Clayshale (75 percent) and siltstone (25 percent). Clayshale like unit 21. Siltstone like unit 17; beds 0.03 to 0.6 ft thick.....	50.4	529.3
14.	Siltstone and very-fine-grained sandstone (50 percent) and clayshale and mudshale (50 percent). Siltstone and sandstone are medium gray (N5) to olive gray (5Y4/1), weather light olive gray (5Y5/2); beds range in thickness from 0.05 ft to 2.4 ft, mode is less than 0.1 ft; planar and cross lamination common; Tb Bouma sequences very common, Tbcde and Tcde sequences less common, Tabc- Tabc- Tabc sequence present in one 2.4 ft thick amalgamated bed; content		

		Thickness (feet) Unit	Cum.
	grading common; some amalgamation of beds; partings 1 cm to 1 mm thick; sharp, planar bases and gradational rippled tops produce pinch and swell; beds increase in abundance downward. Shales like unit 21; texturally laminated and silt-laminated mudshale grades downward into texturally laminated clayshale.....	61.2	478.9
13.	Mudstone (90 percent) and siltstone (10 percent). Mudstone is olive gray (5Y4/1); very irregular subparallel partings 2 to 3 mm thick; interbedded with less than 10 percent clayshale, moderate olive brown (5Y4/4); texturally laminated; silt-free; soft, fissile. Siltstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); beds up to 0.25 ft thick; mode is 0.1 ft; Tc Bouma sequences very common; partings 2 to 3 mm thick.....	52.5	417.7
12.	Siltstone, medium gray (N5) to medium light gray (N6); weathers light olive gray (5Y5/2) with limonitic stain; Tab Bouma sequence; sharp planar base and sharp, undulatory top; parallel partings 3 mm thick in upper 0.4 ft.....	0.9	365.2
11.	Interbedded clayshale and mudshale with interlaminated, cross laminated siltstone less than 1 cm thick. Clayshale is moderate olive brown (5Y4/4); texturally laminated; silt-free; fissile; partings 2 to 3 mm thick. Mudshale is light olive gray (5Y5/2); texturally laminated; irregular partings up to 5 mm thick.....	16.5	364.3
10.	Non-bedded, non-laminated siltstone with few bedded siltstones (70 percent) and clayshale (30 percent). Siltstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2) with limonitic stain; very shaley in indistinct beds; parallel partings 2 to 3 mm thick; abundant horizontal burrows 2 to 5 mm across. Clayshale like unit 11; decreases downward in unit; rare silt laminae less than 1 mm thick.....	5.1	347.8

		Thickness (feet) Unit	Cum.
9.	Siltstone, medium dark gray (N4), weathers light olive gray (5Y5/2); gradational planar base and gradational rippled top; amalgamated; lower 0.6 ft shows Tb Bouma sequence, then shaley parting followed upward by 0.7 ft Tab sequence; 2 to 3 mm thick partings in upper part.....	1.3	342.7
8.	Clayshale (80 percent) and siltstone (20 percent). Clayshale like unit 10; rare 0.1 ft zones of yellowish gray (5Y8/1), highly burrowed claystone. Siltstone is medium gray (N5) weathers olive gray (5Y4/1); beds range in thickness from 0.05 to 0.4 ft thick; Tc Bouma sequences common; rippled upper surfaces give pinch and swell appearance; partings 5 to 10 mm thick; organic sole markings common; horizontal burrows within beds rare.....	100.4	341.4
7.	Clayshale (70 percent) and siltstone (30 percent). Clayshale like unit 10. Siltstone like unit 8 in beds up to 1.1 ft thick; some amalgamation of beds; Tbc and Tc Bouma sequences very common; partings 2 to 5 mm thick; organic sole markings common on few beds.....	25.7	241.0
6.	Clayshale (70 percent) and siltstone (25 percent). Clayshale like unit 10. Siltstone like unit 12 in color; beds up to 0.7 ft thick; planar lamination very common, cross lamination less common; Tc Bouma sequences very common, Tb, and Tbc sequences less common; massive and structureless beds rare; content grading common; partings 2 to 5 mm thick; non-bedded, non-laminated siltstones rare; rare fossils include Liorhyncus sp.....	81.5	215.3
	Total Brallier Formation (incomplete)..	1271.6	

Harrell Shale (incomplete):

5.	Clayshale, moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2) to		

	Thickness (feet) Unit	Cum.
medium gray (N5) to papery and platy chips and less commonly to small blades; texturally laminated; slightly silty; fissile, hard, brittle; partings 1 to 3 mm thick; fossils common include Liorynchus sp. and articulate and disarticulate pelmatazoon columnals.....	28.8	133.8
4. Interbedded clayshale and mudshale. Clayshale is grayish olive (10Y4/2) weathers olive gray (5Y3/2); texturally laminated; fissile, partings 1 to 4 mm thick. Mudshale is medium dark gray (N4) weathers olive gray (5Y4/1) to medium gray (N5); beds up to 0.2 ft thick; silt laminae 1 to 2 mm thick common; irregular, subparallel, hackly partings 1 to 3 mm thick.....	8.0	105.0
3. Clayshale and mudshale (80 percent) and siltstone (20 percent). Shales like unit 4. Siltstone is medium gray (N5), weathers olive gray (5Y4/1) with limonitic stain; beds range in thickness from less than 0.05 ft to 0.2 ft; Tcde and Tbcde Bouma sequences common.....	7.0	97.0
2. Mudshale grades downward into clayshale approximately 5 ft below top. Mudshale is compositionally and texturally laminated with silt laminae less than 1 mm thick; hard, platy. Clayshale is interbedded dusky yellowish brown (10YR2/2) and medium gray (N5). Concretion 0.5 ft in diameter at 11 ft below top.....	60.0	90.0
Burket Member		
1. Clayshale, in deformed zone; black (N1), weathers dark yellowish brown (10YR4/2); silt-free; soft, fissile; papery partings 1 to 2 mm thick; thickness estimated.....	30.0	30.0
Total Harrell Shale.....	133.8	
Total Devonian (incomplete).....	1405.4	

SECTION 6

Junction Section

Incomplete section of lower part of Brallier Formation exposed for 0.25 mile in road cuts along north side of U.S. Highway 220-50, near intersection with U.S. Highway 220-28 south in town of Junction. Base of section located 0.3 mile west of intersection in Junction, Mineral County, West Virginia (Romney quadrangle, 684558 East, 4353610 North, Universal Transverse mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, December 26, 1977.

	Thickness (feet)	
Devonian (incomplete):	Unit	Cum.
Brallier Formation (incomplete):		
11. Mudstone (60 percent) and siltstone (40 percent). Mudstone is moderate olive brown (5Y4/4) weathers light olive gray (5Y5/2) to moderate olive brown (5Y4/4); silt content increases downward; distinct horizontal burrows 3 to 4 mm across; fissility rarely developed; irregular partings 1 to 3 mm thick. Siltstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2) with moderate yellowish brown (10YR5/4) limonitic stain; occurs both as non-bedded, non-laminated siltstone (10 percent of unit) in lower 9 feet of unit and as distinct beds ranging in thickness from 0.05 ft to 0.4 ft, mode is 0.1 ft; planar and cross lamination common; Tac Bouma sequences common in beds greater than 0.3 ft thick, Tbc and Tc sequences also common; organic sole markings rare; sharp, planar bases and gradational, rippled tops.....	14.0	501.0
10. Mudstone (55 percent) and siltstone (45 percent). Mudstone like unit 11. Siltstone like unit 11 in color; beds range in thickness from 0.05 to 0.7 ft thick, mode is less than 0.15 ft; micaceous; cross lamination very common; Tc Bouma sequences most common, Tac sequences less common and Tacd sequences rare; organic and current formed sole markings include fine groove casts oriented 280°; sharp, planar bases and gradational rippled tops.....	18.5	487.0

		Thickness (feet) Unit	Cum.
9.	Clayshale and mudstone (70 percent) and siltstone (30 percent). Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; slightly silty; partings 1 to 3 mm thick; grades into mudstone like unit 11 in upper 10 feet of unit; less than 5 percent highly burrowed, yellowish gray (5Y8/1) claystone. Siltstone like unit 11. Deformed zone between 103.5 and 98.5 ft below top.....	150.5	468.5
8.	Clayshale and claystone (70 percent) and siltstone (30 percent). Clayshale is light olive gray (5Y5/2) weathers dark yellowish orange (10YR6/6) to grayish orange (10YR7/4); biolaminated (color lamination); partings 2 to 3 mm thick; rare highly burrowed claystone. Siltstone like unit 11; beds less than 0.2 ft thick; horizontal burrows common.....	4.0	318.0
7.	Mudstone (70 percent) and siltstone (30 percent). Mudstone like unit 10. Siltstone like unit 8; beds range in thickness from 0.05 to 0.35 ft thick; planar and cross lamination common; Tbc Bouma sequences common; content grading common; partings 1 to 2 mm thick.....	35.0	314.0
6.	Mudstone, weathers yellowish gray (5Y7/2) to light olive gray (5Y5/2); minor beds of highly burrowed claystone 0.1 to 0.2 ft thick.....	11.0	279.0
5.	Mudstone (80 percent) and siltstone (20 percent) like unit 11.....	34.8	268.0
4.	Siltstone and very-fine-grained sandstone (75 percent) and clayshale (25 percent). Siltstone and sandstone are olive gray (5Y4/1) weather moderate olive brown (5Y4/4); micaceous; beds range in thickness from 0.15 ft to 3.4 ft; some amalgamation of beds; cross lamination common in beds less		

		Thickness (feet) Unit	Cum.
	than 0.4 ft thick; Ta Bouma sequences in beds thicker than 0.4 ft; load casts common; content graded; organic sole markings common in few beds. Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; slightly silty; partings 1 to 3 mm thick. Beds strike 220°, dip 24° SE.....	9.2	233.2
3.	Siltstone (20 percent increases downward to 60 percent) and mudstone (80 percent decreases downward to 40 percent). Siltstone occurs both as distinct beds like unit 11 and as non-bedded, non-laminated siltstone, the latter predominates in the lower 10 ft of unit. Mudstone like unit 10 with minor highly burrowed claystone.....	58.0	224.0
2.	Covered.....	46.0	166.0
1.	Siltstone (20 percent increases downward to 70 percent) and mudstone and clayshale (80 percent decreases downward to 30 percent). Siltstone like unit 3. Mudstone grades downward into clayshale like unit 8 with minor burrowed claystone.....	120.0	120.0
	Total Brallier Formation (incomplete)..	501.0	

SECTION 7

Ridgeville Section

Incomplete section of Upper Devonian including uppermost Harrell Shale and lower one half of Brallier Formation exposed for 0.5 mile in road cuts along north side of U.S. Highway 50-220 approximately 2 miles west of Burlington, Mineral County, West Virginia (Burlington Quadrangle). Top of section located approximately 0.9 mile east of Ridgeville, about 200 feet west of sign for Stone House Inn and across from drainage pipe (674250 East, 4356250 North, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, December 23-25, 1977.

Devonian (incomplete):

	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
15. Siltstone (65 percent) and mudstone with minor mudshale (35 percent). Siltstone is olive black (5Y2/1); beds up to 1.5 ft thick, modal thicknesses of 0.05 and 0.3 ft; some amalgamation of beds; cross lamination common; Tac and Tae Bouma sequences common; organic and current formed sole markings common include fine groove casts oriented 274°, 278°, 280°, and 282°; sharp, planar bases and gradational, rippled tops; content graded. Mudstone is moderate olive brown (5Y4/4) to olive gray (5Y4/1), weathers light olive gray (5Y5/2) to small chips; distinct horizontal burrows 2 to 3 mm across common in some horizons.....	42.6	1243
14. Mudstone (75 percent), siltstone (20 percent) and claystone (5 percent). Mudstone like unit 15. Siltstone is moderate olive brown (5Y4/4); weathers to small angular blocks; beds range in thickness from less than 0.05 ft to 0.8 ft; cross lamination common; Tac Bouma sequences common; organic sole markings common; content graded; parting thickness generally decreases upward in beds to 1 to 2 mm. In few intervals up to 5 ft thick, siltstone may be 40 percent. Claystone is yellowish gray (5Y8/1); beds less than 0.15 ft thick; highly bioturbated with indistinct horizontal burrows abundant; forms slight recesses on outcrop.....	142.4	1200.4
13. Mudstone (95 percent) and siltstone (5 percent). Mudstone like unit 15. Siltstone in beds less than 0.05 ft thick; planar and cross lamination common; Tbc Bouma sequences.	60.0	1058.0
12. Covered.....	113.0	998.0

NOTE: Unit 11 contains zones of folded strata but can be described in its entirety.

11. Mudstone and clayshale (65 percent) and siltstone (35 percent). Mudstone like unit 15. Clayshale predominant in upper 25 feet of		

		Thickness (feet) Unit	Cum.
	unit; texturally laminated; partings 1 to 3 mm thick. Rare, highly burrowed claystone in zones up to 0.5 ft thick in lower one half of unit. Siltstone is medium dark gray (N4), weathers light olive gray (5Y5/2) to small angular blocks; percent siltstone decreases downward; bed range in thickness from less than 0.05 ft to 0.4 ft; cross lamination very common; 90 percent of beds with Tc Bouma sequence; content graded; carbonized wood fragments common along some bedding planes; organic sole markings common; sharp, planar bases and gradational rippled tops give pinch and swell effect to thinner beds.....	275.0	885.0
10.	Covered (probably like unit 11).....	25.0	610.0
9.	Mudstone (65 percent) and siltstone (35 percent); like unit 11.....	37.0	585.0
8.	Clayshale (90 percent, decreases downward to 70 percent) and siltstone (10 percent increases downward to 30 percent). Clayshale is grayish olive (10Y4/2), weathers olive gray (5Y4/1) to small, thin chips; texturally laminated; silt-free; fissile; partings 1 to 3 mm thick. Siltstone is grayish olive (10Y4/2); beds less than 0.3 ft thick; Tac Bouma sequences common; content graded.....	34.0	548.0
7.	Siltstone (80 percent) and mudstone (20 percent). Siltstone is olive black (5Y2/1); both as distinct beds less than 1.0 ft thick and as non-bedded, non-laminated siltstone in upper part of unit; bedded siltstones show Tae and Tac Bouma sequences; content graded; rippled upper surfaces. Mudstone is olive black (5Y2/1) weathers olive gray (5Y3/2); irregular partings. Beds strike 224°, dip 25° SE.....	31.0	514.0
6.	Clayshale (90 percent) and siltstone (10 percent). Clayshale is olive gray (5Y3/2), weathers olive gray (5Y3/2) to small thin chips; texturally laminated; silt-free to		

		Thickness (feet) Unit	Cum.
	very slightly silty; rare silt laminae few grains thick. Siltstone like unit 7 in beds less than 0.05 ft thick except for one bed 0.4 ft thick at 5.5 ft below top; cross lamination very common; non-bedded, non-laminated siltstone common in upper part....	55.0	483.0
5.	Siltstone (40 percent), non-bedded, non-laminated siltstone (40 percent) and mudstone (20 percent). Siltstones like unit 6 in beds up to 0.35 ft thick. Mudstone is olive black (5Y2/1) weathers medium dark gray (N4) to varisized chips.....	23.0	428.0
4.	Mudstone (90 percent) and siltstone (10 percent). Mudstone is olive gray (5Y3/2) weathers olive gray (5Y4/1) to small chips and small blocks 2 to 3 cm thick; spheroidal weathering present; rare distinct horizontal burrows 3 to 4 mm across; irregular partings. Rare, yellowish gray (5Y8/1) highly burrowed claystone. Siltstone is medium dark gray (N4), weathers light olive gray (5Y5/2) with limonitic stain; beds generally less than 0.1 ft thick with one 0.35 ft thick bed at 25 ft below top; cross lamination very common; 90 percent of beds contain Tc Bouma sequence; content graded; partings 2 to 3 mm thick. Beds strike 223°, dip 30° SE.....	155.0	405.0
3.	Covered.....	40.0	250.0
2.	Mudstone (80 percent) and siltstone (20 percent). Mudstone is olive black (5Y2/1), weathers olive gray (5Y4/1) to medium gray (N5); horizontal burrows common; highly fractured; irregular partings. Siltstone is olive gray (5Y4/1) weathers to slightly elongate angular blocks; beds range in thickness from 0.05 ft to 0.8 ft, mode is less than 0.1 ft; Tae Bouma sequences common, Tc sequences less common; rippled upper surfaces.....	180.0	210.0
	Total Brallier Formation (incomplete)..	1213.0	

	Thickness (feet) Unit	Cum.
Harrell Shale (incomplete):		
1. Clayshale (95 percent) and siltstone (5 percent). Clayshale is dusky yellowish brown (10YR2/2), weathers medium dark gray (N4); texturally laminated; slightly silty; distinct horizontal burrows rare; irregular platy partings 2 to 3 mm thick. Siltstone is dusky yellowish brown (10YR2/2), weathers with limonitic stain; beds less than 0.1 ft thick; cross lamination common; sharp planar bases and gradational tops; partings 2 mm thick.....	30.0	30.0
Total Harrell Shale (incomplete).....	30.0	
Total Devonian (incomplete).....	1243.0	

SECTION 8

Montrose Section

Incomplete section of Brallier Formation exposed along east side of U.S. Highway 219 in town of Montrose. Base of section located at north end of exposure across from Nestors Service Station, Randolph County, West Virginia (Montrose Quadrangle, 602870 East, 4325000 North, Universal Transverse Mercator grid). Good exposure of Facies A. Section measured, described, and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, April 3, 1978.

	Thickness (feet) Unit	Cum.
Devonian (incomplete):		
Brallier Formation (incomplete):		
1. Clayshale (70 percent) and siltstone (30 percent). Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; silt-free to silty; thin silt laminae less than 1 mm thick common; weathered partings 1 to 3 mm thick, fresh partings 5 to 10 mm thick. Siltstone is light olive gray (5Y5/2); beds less than 0.25 ft thick, mode is less than 0.1 ft; cross lamination very common; Tc Bouma sequences; sharp, planar bases and gradational rippled tops; current formed sole markings include		

	Thickness (feet) Unit	Cum.
groove casts near top of unit oriented 300° and 304°. Beds strike 302°, dip 35° SE.....	130.0	
Total Brallier Formation (incomplete)..	130.0	

SECTION 9

Stalnaker Road Section

Incomplete section of Brallier Formation exposed for 0.1 mile in road cut along north side of Stalnaker Road, 0.35 mile east of U.S. Highway 219, approximately 4.5 miles north of Elkins, Randolph County, West Virginia (Elkins Quadrangle). Base of section located beneath large solitary tree across from C.M. Smith residence, (601557 East, 4315721 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, November 4, 1977.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
3. Clayshale (80 percent decreases downward to 50 percent) and siltstone (20 percent increases downward to 50 percent). Clayshale is light olive brown (5Y5/6) to moderate olive brown (5Y4/4); texturally laminated; slightly silty; rare silt laminae less than 0.5 mm thick; distinct horizontal burrows very rare; partings 1 to 3 mm thick. Siltstone is olive gray (5Y4/1) to light olive gray (5Y5/2) in beds less than 0.25 ft thick; cross lamination very common, planar lamination less common; Tc and Tbc Bouma sequences common; sharp planar bases and gradational rippled tops; non-bedded, non-laminated siltstone comprises less than 5 percent of unit.....	35.0	75.1
2. Siltstone (70 percent) and clayshale (30 percent). Siltstone is dark greenish gray (5GY4/1); beds range in thickness from 0.05 ft to 1.1 ft; beds greater than 0.3 ft generally show Ta Bouma sequences, those thinner than 0.3 ft commonly show Tc sequences; sharp, planar bases and gradational,		

	Thickness (feet) Unit	Cum.
rippled tops; organic sole markings common; carbonized wood fragments abundant along some bedding planes. Clayshale is light olive gray (5Y5/2) to moderate olive brown (5Y4/4); weathers to chips up to 1 cm thick; texturally laminated; silt-free to slightly silty; rare very thin silt laminae, rarely cross laminated. Beds strike 210°, dip 18° SE.....	9.8	40.1
1. Siltstone (50 percent) and clayshale (50 percent). Siltstone like unit 3 in beds generally less than 0.2 ft thick, mode is less than 0.1 ft; current formed sole markings include flute mark oriented 298° and groove cast oriented 295°. Clayshale like unit 3; less silty.....	30.3	30.3
Total Devonian (incomplete).....	75.1	

SECTION 10

Roney Run Section

Incomplete section of Brallier Formation exposed for 0.2 mile in road cuts along east side of road between Gilman and Read, 0.6 mile southeast of intersection with U.S. Highway 219, approximately 2.0 miles north of Elkins, Randolph County, West Virginia (Elkins Quadrangle). Base of section located approximately 150 feet south of NO DUMPING sign on west side of road (600673 East, 4313520 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, November 6, 1977.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
5. Siltstone (70 percent increases downward to 90 percent) and mudshale (30 percent decreases downward to 10 percent). Siltstone is olive gray (5Y3/2), weathers light olive gray (5Y5/2) with limonitic stain; lower 20 ft of unit contains 30 to 40 beds ranging		

		Thickness (feet) Unit	Cum.
	from 0.1 ft to 0.9 ft thick, mode is about 0.5 ft; some amalgamation of beds; Tc and Tbc Bouma sequences equally abundant; sharp, planar bases and gradational, rippled tops; organic and current-formed sole markings rare; upper 8.7 ft of unit contains fewer and thinner beds. Mudshale is olive gray (5Y3/2); texturally laminated; silt occurs both disseminated and in rare laminae about 1 mm thick. Beds strike 200°, dip 22° SE.....	28.7	138.0
4.	Siltstone (60 percent) and mudstone (40 percent). Siltstone is grayish olive (10Y4/2); beds range in thickness from 0.05 ft to 0.6 ft, generally decrease in thickness downward; Tbc and Tc Bouma sequences common; sharp, planar bases and gradational rippled tops. Mudstone is olive gray (5Y4/1) to moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); irregular partings 2 to 8 mm thick.....	11.3	109.3
3.	Clayshale with minor mudshale (60 percent) and siltstone (40 percent). Clayshale is olive gray (5Y4/1), weathers olive gray (5Y4/1) to light olive gray (5Y5/2); texturally laminated; silt-free with exception of rare silt laminae less than 0.5 mm; distinct horizontal burrows rare. Siltstone is light olive gray (5Y5/2); beds less than 0.1 ft thick except one 0.8 ft bed at 7 ft below top; cross lamination and planar lamination common; Tc and Tbc Bouma sequences common; 0.8 ft bed shows Tae Bouma sequence.	63.4	98.0
2.	Siltstone and very-fine-grained sandstone (80 percent) and mudshale (20 percent). Siltstone is light olive gray (5Y5/2) to olive gray (5Y3/2) weathers with limonitic stain; beds range in thickness from 0.05 ft to 2.8 ft thick, mode is between 0.5 and 0.7 ft; Tbc and Tbcd Bouma sequences common; rare current formed sole markings, include groove casts oriented 310° and 295°, organic sole markings very common; micaceous partings		

		Thickness (feet) Unit	Cum.
	3 to 15 mm thick common. Base of unit marked by 1.4 ft thick bed of very-fine-grained sandstone; moderate brown (5YR3/4), highly weathered; contains abundant shell debris casts, segregated into layers about 1 cm thick with thinner interlayers containing fewer casts; shale rip-up clasts common. Mudshale is moderate olive brown (5Y4/4) to olive gray (5Y3/2), weathers light olive gray (5Y5/2); texturally laminated; thin silt laminae rare; partings 1 to 3 mm thick.	29.8	34.6
1.	Mudshale (70 percent) and siltstone (30 percent). Mudshale like unit 2. Siltstone is moderate olive brown (5Y4/4) weathers light olive gray (5Y5/2); beds less than 0.15 ft thick, mode is about 0.03 ft; Tc Bouma sequence common, Tae sequence less common; rippled upper surfaces.....	4.8	4.8
	Total Brallier Formation (incomplete)..	138.0	

SECTION 11

Sugar Run Section

Incomplete section of Brallier Formation exposed for 0.25 mile in road cuts along west side of road between Gilman and Read, approximately 1.5 miles north of Elkins, Randolph County, West Virginia (Elkins Quadrangle). Base of section located directly across from mailbox of W. Workman (SR Rt. 2) 0.5 mile north of Read (600500 East, 4313481 North, Universal Transverse Mercator grid). Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, November 5, 1977.

Devonian (incomplete):		Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):			
10.	Claystone with very minor siltstone. Very badly weathered. Claystone weathers dark yellowish orange (10Y6/6), to chips and small blocks up to 1 cm thick; silt-free....	9.5	273.0

		Thickness (feet) Unit	Cum.
9.	Siltstone (60 percent) and claystone with minor clayshale (40 percent). Badly weathered. Siltstone in beds up to 0.5 ft thick; cross lamination common; sharp, planar bases and gradational, rippled tops. Claystone like unit 10 with texturally laminated clayshale in lower part.....	45.5	263.5
8.	Clayshale (65 percent) and siltstone (35 percent). Clayshale is moderate olive brown (5Y4/4), weathers dark yellowish brown (10Y6/6); texturally laminated; silt-free to slightly silty; rare silt laminae less than 1 mm thick; distinct horizontal burrows 2 to 4 mm across common. Siltstone is moderate olive brown (5Y4/4), weathers dark yellowish orange (10Y6/6); beds range in thickness from 0.05 ft to 0.9 ft; cross lamination very common; Tac and Tc Bouma sequences common; organic sole markings rare.....	62.4	218.0
7.	Clayshale with less than 5 percent siltstone. Clayshale is moderate olive brown (5Y4/4) to grayish olive (10Y4/2), weathers dark yellowish orange (10Y6/6) to moderate olive brown (5Y4/4); texturally laminated; like unit 8; becomes siltier downward. Siltstone like unit 8 in beds less than 0.2 ft thick; Tc Bouma sequences common.....	51.0	155.6
6.	Clayshale (60 percent) and siltstone (40 percent). Clayshale like unit 7. Siltstone like unit 8 in beds up to 0.6 ft thick; Tae Bouma sequences common, Tc sequences less common.....	12.6	104.6
5.	Siltstone (75 percent) and clayshale (25 percent). Siltstone is olive gray (5Y4/1) to moderate olive brown (5Y4/4); beds range in thickness from 0.05 ft to 0.8 ft, mode is 0.15 to 0.25 ft; cross lamination very common; Tc Bouma sequences common, Tac sequences less common; sharp, planar bases and gradational rippled tops; organic sole markings common. Clayshale like unit 7.....	10.0	92.0

		Thickness (feet) Unit	Cum.
NOTE:	Fault with unknown displacement separates units 5 and 4.		
4.	Poorly exposed, clayshale like unit 7.....	6.0	82.0
3.	Poorly exposed. Siltstone (80 percent) and clayshale (20 percent). Siltstone is olive gray (5Y4/1); beds range in thickness from 0.05 ft to 1.4 ft, mode is less than 0.2 ft; some amalgamation of beds; planar lamination common; carbonized wood fragments abundant along some bedding planes; partings 5 to 10 mm thick. Clayshale like unit 7.....	15.8	76.0
2.	Siltstone (50 percent) and clayshale (50 percent). Siltstone is moderate olive brown (5Y4/4); beds generally less than 0.1 ft thick with exception of one 0.6 ft dark greenish gray (5Y4/1) bed; planar lamination very common, cross lamination less common; Tb, Tbc and Tc Bouma sequences common. Clayshale is moderate olive brown (5Y4/4) to olive gray (5Y2/2); texturally laminated; slightly silty; partings 1 to 2 mm thick.....	37.2	60.2
1.	Poorly exposed. Siltstone (70 percent) and clayshale (30 percent). Siltstone like unit 2 in beds up to 0.9 ft thick, mode is 0.2 ft; some amalgamation of beds; Tae and Tabe Bouma sequences common. Clayshale like unit 2.....	23.0	23.0
	Total Brallier Formation (incomplete)..	273.0	

SECTION 12

Elkins Section

Incomplete section of Brallier Formation exposed for 0.1 mile in cuts behind stores along south side of U.S. Highway 33 immediately east of intersection with U.S. Highway 250 in Elkins, Randolph County, West Virginia (Elkins Quadrangle). Base of section located at eastern end of exposure behind construction vehicles approximately 250 yards

west of intersection (600413 East, 4307023 North, Universal Transverse Mercator grid). Section measured, described and sampled by Neil D. Samuels, September 22, 1978.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
5. Clayshale (65 percent) and siltstone (35 percent). Clayshale is olive gray (5Y4/1) to moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; silt-free to slightly silty; partings 1 to 3 mm thick. Siltstone is olive gray (5Y4/1) weathers with moderate yellowish brown (10YR5/4) to grayish brown (5YR3/2) limonitic stain; beds range in thickness from less than 0.05 ft to 2.2 ft, mode is less than 0.2 ft, thickness increases downward; cross lamination very common, planar lamination less common; Tc and Tbc Bouma sequences common; thicker beds often with Tabc, or Tac sequences; sharp, planar bases and gradational, rippled tops; linguoid current ripples with wavelengths of about 0.25 ft and heights of 5 mm commonly cover upper surfaces; trace fossils include Chondrites.....	60.0	245.1
4. Deformed zone with excellent examples of chevron folds, then covered. Thickness estimated.....	60.0	185.1
3. Clayshale (65 percent) and siltstone (35 percent) like unit 5. Siltstone in beds generally less than 0.3 ft thick; more abundant in upper 20 ft.....	66.7	125.1
2. Siltstone and very-fine-grained sandstone (70 percent) and clayshale (30 percent). Siltstone and sandstone like unit 5; beds range in thickness from 0.05 ft to 1.7 ft, mode is between 0.1 and 0.2 ft with many beds 0.4 to 0.6 ft thick. Clayshale like unit 5.....	22.8	58.4
1. Mudshale (95 percent) with minor clayshale and siltstone (5 percent). Mudshale is olive gray (5Y4/1) weathers moderate yellowish brown (10YR5/4) to grayish brown		

	Thickness (feet) Unit	Cum.
(5YR3/2) to small chips and blades; texturally laminated; irregular subconchoidal partings 2 to 10 mm thick. Siltstone like unit 5 in beds less than 0.2 ft thick, mode is 0.05 ft.....	35.6	35.6
Total Brallier Formation (incomplete)..	245.1	

SECTION 13

Back Road Section

Incomplete section of upper part of the Brallier Formation exposed for 0.3 mile in road cuts along north side of Back Road just east of intersection with U.S. Highway 219-250, Randolph County, West Virginia (Beverly West quadrangle). Base of section is located at stop sign at intersection (597055 east, 4296000 north, Universal Transverse Mercator grid). Units 1 through 4 described in order from base of section upward, followed by a deformed zone. Description continues approximately 300 feet east, directly across from a drainage pipe. Section ends at the base of a long deformed zone. Section measured, described and sampled using Jacob's staff, Abney level, tape and compass by Neil D. Samuels, November 10, 1978.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
12. Mudshale (70 percent) with minor clayshale and siltstone (30 percent). Mudshale is light olive gray (5Y5/2) to moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2) to small chips; texturally laminated; rare silt laminae less than 1 mm thick; soft, fissile; partings 1 to 2 mm thick. Siltstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2) with limonitic stain; beds range in thickness from less than 0.05 ft to 0.5 ft, mode is less than 0.05 ft; single set cross lamination common; Tc Bouma sequences very common, Tbc sequences present in thicker beds; sharp, planar bases; zone between 7 and 12 ft below top is approximately 70 percent siltstone in beds with modal thickness of 0.1 ft.....	32.5	380.0

		Thickness (feet) Unit	Cum.
11.	Siltstone and very-fine-grained sandstone (60 percent) and mudshale (40 percent). Siltstone and sandstone are medium light gray (N6) to dusky yellowish brown (10YR2/2); beds range in thickness from 0.05 ft to 1.1 ft; planar and cross lamination common; Tbc Bouma sequence common in thicker beds, Tc sequence also common; organic sole markings common, rare current-formed sole markings include groove casts oriented 301°. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2) with limonitic stain; texturally laminated; abundant silt laminae less than 1 mm thick; partings 1 mm thick.....	15.5	347.5
10.	Clayshale (90 percent) with minor mudshale and siltstone (10 percent). Clayshale is brownish black (5YR2/1), weathers light olive gray (5Y5/2); texturally laminated; slightly silty, partings 1 to 2 mm thick; mudshale present in upper 3 ft of unit. Siltstone is olive gray (5Y4/1) to medium light gray (N5); beds range in thickness from 0.05 to 0.5 ft, mode is 0.05 to 0.1 ft; beds decrease in abundance and thickness downward from 60 percent in upper 3 ft to 10 percent near base.....	27.8	332.0
9.	Siltstone and very-fine-grained sandstone (90 percent decreases downward to 40 percent) and clayshale and mudshale (10 percent increases downward to 60 percent). Siltstone and sandstone form "packet" in upper 14 ft of unit with beds ranging in thickness from 0.1 ft to 2.1 ft, six beds greater than 1.3 ft thick; massive and structureless beds, amalgamation of beds and load casts common; sharp bases and rippled upper surfaces. Siltstone beds in rest of unit have modal thickness of 0.15 ft; organic sole markings common include Pteridichnites biseriatus. Clayshale like unit 10 except for slightly lighter color, grades downward into mudshale like unit 11 but lacks silt laminae.....	20.0	304.2

		Thickness (feet) Unit	Cum.
8.	Clayshale (90 percent) and siltstone (10 percent). Clayshale like unit 10 except siltier and lighter in color in upper part of unit. Siltstone is olive gray (5Y4/1) to light olive gray (5Y5/2) weathers light olive gray (5Y5/2); beds range in thickness from 0.05 to 0.3 ft with mode of 0.1 ft; Tac and Tc Bouma sequences present; rippled upper surfaces; zone between 5 and 7 ft below top is 30 percent siltstone.....	30.2	284.2
7.	Clayshale and mudshale (80 percent decreases to 30 percent in lower 4 feet) and siltstone (20 percent increases to 70 percent downward). Shales like unit 10. Siltstone is medium gray (N5), weathers with dark yellowish orange (10YR6/6) to moderate yellowish brown (10YR5/4) limonitic stain; beds range in thickness from less than 0.05 to 0.65 ft with mode of 0.2 ft and secondary mode of less than 0.05 ft, beds increase in thickness downward; organic and current formed sole markings include groove casts oriented 280°; sharp bases, generally planar with sharp, rippled tops; massive, blocky.....	11.0	254.0
6.	Deformed zone, like unit 7.....	13.5	243.0
5.	Siltstone and very-fine-grained sandstone (10 percent increases to 60 percent at 8 ft below top) and clayshale (90 percent decreases to 40 percent). Siltstone and sandstone are dusky yellowish brown (10YR2/2), weather with moderate yellowish brown (10YR5/4) limonitic stain; beds range in thickness from less than 0.05 to 0.8 ft, mode is between 0.1 and 0.2 ft, lateral thickness variation common; structureless beds common, cross lamination in upper parts of approximately 20 percent of beds; sharp planar bases and gradational rippled tops; content grading common; blocky and highly fractured. Upper 8 ft of unit contains only 3 or 4 siltstone beds. Clayshale weathers light olive gray (5Y5/2) to medium light gray (N6) with limonitic stain;		

		Thickness (feet) Unit	Cum.
	texturally laminated; silt free; partings 1 to 2 mm thick.....	24.0	229.5
4.	Mudshale (50 percent) clayshale (40 percent) and siltstone (10 percent). Shales are olive gray (5Y4/1) weather olive gray (5Y4/1) to light olive gray (5Y5/2); texturally laminated; partings 1 to 3 mm thick. Clayshale predominates in upper half of unit, grades downward into mudshale; rare highly burrowed yellowish gray (5Y8/1) claystone. Siltstone is medium light gray (N6), weathers medium gray (N5); beds generally less than 0.1 ft thick; beds more abundant in lower fourth of unit; cross lamination common; Tc Bouma sequences common, Tbc sequences less common; vertical and horizontal burrows rare.....	94.5	205.5
3.	Siltstone and very-fine-grained sandstone (70 percent) and mudshale and clayshale (30 percent). Siltstone and sandstone are medium light gray (N6) weather medium gray (N5) with brownish gray (5YR4/1) to dark yellowish brown (10YR4/2) limonitic stain; beds range in thickness from less than 0.05 ft to 3.0 ft and are arranged in two thinning upward sequences - one from 22.5 to 11.5 ft below top, the other from the base of unit to 17.5 ft above base; lateral thickness changes present; some amalgamation of beds; planar and cross lamination common; Tc Bouma sequences common in beds less than 0.3 ft thick, Tab, Tabc sequences common in thicker beds; organic- and current-formed sole markings common, include groove casts at 38 ft below top oriented 235°, other groove casts with average orientation of 270°, and 278°; sharp bases and gradational, rippled tops; content grading common; parting thickness generally decrease upward in beds from greater than 1 cm to 1 mm. Shales are olive gray (5Y4/1) to moderate olive brown (5Y4/4), weather olive gray (5Y4/1) to light olive gray (5Y5/2); texturally laminated; rare thin waxy, lustrous zones with slickensides.....	53.5	111.0

		Thickness (feet) Unit	Cum.
2.	Mudshale with minor clayshale (60 percent) and siltstone and very-fine-grained sandstone (40 percent). Mudshale is like unit 3; partings 1 to 2 mm thick. Siltstone and sandstone are medium gray (N5), weather olive gray (5Y4/1); beds range in thickness from less than 0.05 ft to 1.3 ft, mode is less than 0.2 ft, beds decrease in thickness and abundance upward to 7.5 ft below top, then increase upward into unit 3; slight lateral thickness variations and some amalgamation of beds; planar and cross lamination common; Tbc Bouma sequences most common, Tc and Tab sequences less common; very rare, highly calcareous, blocky beds less than 0.15 ft thick at 12.8 ft below top, with common fossils including small unidentifiable brachiopod and pelmatazoon debris; carbonized wood fragments common along some bedding planes; generally sharp bases and both sharp and gradational, rippled tops.....	4.5	57.5
1.	Clayshale (60 percent) and siltstone and very-fine-grained sandstone (40 percent). Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; silt-free; partings 1 to 3 mm thick. Siltstone and sandstone are light olive gray (5Y6/1) to medium gray (N5), weather olive gray (5Y4/1) with brownish gray (5YR4/1) limonitic stain; beds range in thickness from 0.05 ft to 1.7 ft, mode is 0.1 ft; planar and cross lamination common; Tbc and Tc Bouma sequences common; generally sharp bases and gradational tops.....	13.0	13.0
	Total Brallier Formation (incomplete)..	380.0	

SECTION 14

Rt. 250 Section

Incomplete section of the lower one half of the Brallier Formation exposed for 0.6 mile in road cuts along south side of U.S. Highway 250, 1.1 miles west of town of Head Waters, Highland County, Virginia (McDowell Quadrangle). Base of section located approximately 80 feet east of Cowpasture River at first curve in road (636635 East, 4242923 North, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, tape and compass and gamma-ray profile taken with scintillometer by Paul D. Lundegard and Neil D. Samuels, Aug. 29-30, 1977 and June 6-9, 1978.

Devonian (incomplete):	Thickness (feet)	
Brallier Formation (incomplete):	Unit	Cum.
36. Mudstone and very minor claystone (80 percent) and siltstone and very-fine-grained sandstone (20 percent). Mudstone is olive gray (5Y4/1); rare, distinct horizontal burrows 3 to 5 mm across and about 3 cm long; parting thickness is variable up to 1 cm. Siltstone and very-fine-grained sandstone in beds 0.05 to 1.0 ft thick, mode is about 0.1 ft; groups of 3 or 4 beds 0.3 - 0.6 ft thick common, amalgamation of beds rare; ripple lamination common in beds less than 0.2 ft thick; Ta Bouma sequences predominate in thicker beds; current formed sole markings include bulbous flute marks at 2.4 ft above base oriented 298° and 305° with blunt ends toward east...	61.4	1385.4
35. Interbedded mudstone and clayshale (70 percent) and siltstone (30 percent). Mudstone shows rare silt laminae less than 1 mm thick; spheroidal weathering common; clayshale is texturally laminated; silt-free; partings 1 to 5 mm thick. Siltstone in beds up to 0.25 ft thick, mode is 0.1 to 0.15 ft; ripple lamination very common; Tcd Bouma sequences common; sharp, planar bases and gradational tops.....	25.6	1324.0
34. Claystone, olive gray (5Y4/1), weathers light olive gray (5Y5/2) to subconchoidal chunks; silt-free to slightly silty; rare silt laminae 1 to 2 mm thick; rare 1 cm thick		

	Thickness (feet) Unit	Cum.
silt layers with planar lamination; abundant, indistinct, yellowish gray (5Y8/1) burrows locally form biolamination (color lamination) 1 to 2 mm thick.....	8.2	1298.4
33. Siltstone (50 percent) mudstone (25 percent) and clayshale (25 percent). Siltstone is in 14 beds up to 1.0 ft thick, mode is 0.2 to 0.3 ft; Ta Bouma sequences common, Tbcd, Tcd sequences less common. Mudstone shows partings 2 to 5 mm thick. Clayshale in upper one third of unit; texturally laminated; silt-free; partings less than 2 mm thick.....	10.2	1290.2
32. Mudstone and interbedded claystone (80 percent) and siltstone (20 percent). Mudstone and claystone are light olive gray (5Y5/2) to moderate olive brown (5Y4/4) weather light olive gray (5Y5/2). Mudstone shows rare silt laminae less than 1 mm thick; rare, distinct horizontal burrows; spheroidal weathering common. Claystone comprises less than 20 percent of unit; indistinct, yellowish gray (5Y8/1) horizontal burrows very common. Siltstone in beds 0.05 to 0.6 ft thick, mode is 0.2 ft; Tc Bouma sequences common, Tbc sequences rare; non-bedded, non-laminated siltstone comprises less than 10 percent of unit.....	39.8	1280.0

NOTE: Low angle fault separates units 32 and 31. Section description continued near top of upper fault block.

31. Claystone with minor mudstone and clayshale (85 percent) and siltstone (15 percent). Claystone, clayshale and mudstone are olive gray (5Y4/1); claystone is silt-free; both claystone and mudstone show common, distinct horizontal burrows 3 to 5 mm across; spheroidal weathering common; partings 2 to 4 mm thick. Clayshale is compositionally laminated with quartz silt laminae 1 mm thick or less. Siltstone in beds up to 0.6 ft thick, mode is 0.1 ft or less; Tc Bouma sequences common in beds less than 0.2 ft thick; planar and cross lamination common;		

		Thickness (feet) Unit	Cum.
	Ta and Tb sequences common in thicker beds; siltstone also occurs as indistinctly bedded layers up to 1.5 cm thick.....	100.2	1240.2
30.	Claystone, yellowish gray (5Y8/1); silt-free, intensely bioturbated with indistinct, horizontal burrows; forms slight recess on outcrop face.....	3.0	1140.0
29.	Mudstone (90 percent) and siltstone (10 percent). Mudstone shows distinct horizontal burrows 3 to 5 mm across; partings 5 to 10 mm thick; spheroidal weathering common. Siltstone in beds up to 0.3 ft thick, mode is 0.2 ft; Tbc and Tc Bouma sequences common.....	13.5	1137.0
28.	Interbedded mudstone and claystone (85 percent) and siltstone (15 percent). Interbedded mudstone and slightly silty claystone show rare silt laminae less than 1.5 mm thick and distinct horizontal burrows 3 to 5 mm across. Claystone in lower 1.0 ft of unit in beds up to 0.2 ft thick; indistinct, yellowish gray horizontal burrows abundant. Siltstone occurs predominantly in upper 4 feet of unit in one bed 1.5 ft thick plus a few beds 0.2 to 0.4 ft thick; thinner beds with Tc Bouma sequences common in lower part of unit.....	18.5	1123.5
27.	Covered.....	10.0	1105.0
26.	Mudstone (45 percent) mudshale (40 percent) with interbedded claystone (10 percent) and siltstone (5 percent). Mudstone is olive gray (5Y4/1) weathers moderate olive brown (5YR4/4) to small brittle chips; distinct horizontal burrows 3 to 5 mm across common; irregular partings 5 mm thick. Mudshale predominates from 18 ft to 34 ft below top; like mudstone in color but compositionally laminated; abundant silt laminae less than 1 mm thick; horizontal burrows very rare; partings 1 to 3 mm thick. Claystone occurs as highly burrowed thin interbeds in mudstone		

	Thickness (feet) Unit	Cum.
and mudshale. Siltstone in beds up to 0.6 ft thick, mode is less than 0.15 ft; Tbc Bouma sequences rare.....	50.7	1095.0
25. Siltstone (85 percent) and clayshale (15 percent). Siltstone is in five beds, from top to bottom of unit the thickness and Bouma sequence of each bed is: 0.3 ft (Tab), 0.45 ft (Tbc), 0.3 ft (Tb), 1.6 ft (Tb) and 0.5 ft; micaceous. Clayshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); texturally laminated; distinct horizontal burrows 3 to 5 mm across; partings 1 to 3 mm thick.....	3.8	1044.3

NOTE: Fault of unknown displacement separates units 24 and 25. Section continues on upper block of fault.

24. Mudstone (90 percent) and siltstone (10 percent). Mudstone shows distinct horizontal burrows 3 to 5 mm across; partings 2 to 5 mm thick. Siltstone in a few beds 0.2 to 0.6 ft thick plus approximately 10 beds less than 0.1 ft thick.....	25.9	1040.5
23. Mudstone and clayshale with very minor claystone (55 percent) and siltstone (45 percent). Mudstone is very silty; partings up to 1.5 cm thick. Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); texturally laminated; rare silt laminae less than 0.5 mm thick. Covered zone between 26.4 to 30.4 ft below top contains no obvious resistant beds. Siltstone in beds up to 2.2 ft thick, mode is less than 0.2 ft, mean is 0.35 ft; some amalgamation of beds; Tc Bouma sequences common, Ta and Tbc sequences also present; sole markings include groove casts at 17 ft below top oriented ?4?°, and flute marks at 48 and 49 ft below top oriented 308°, 302°, 277°, 280°, and 287° with blunt ends toward east. Beds strike 133° dip 41° SE.....	62.9	1014.6
22. Mudstone, with minor clayshale near top of unit, grades downward into claystone, and		

		Thickness (feet) Unit	Cum.
	less than 5 percent siltstone. Mudstone, claystone and clayshale are olive gray (5Y7/1) to moderate olive brown (5YR4/4), weather light olive gray (5Y5/2). Mudstone shows irregular partings 2 to 5 mm thick. Clayshale is slightly silty; partings 2 to 3 mm thick. Claystone is silt-free; distinct horizontal burrows 3 to 5 mm across common. At 21.4 ft below top is a 0.6 ft zone of claystone with abundant, indistinct yellowish gray burrows. Siltstone in beds up to 0.3 ft thick, mode is less than 0.15 ft; Ta and Tb Bouma sequences common.....	46.7	951.7
21.	Very poorly exposed. Mudstone and claystone like unit 18 with several resistant siltstone beds; one 0.7 ft bed in middle of unit.....	18.0	905.0
20.	Mudstone (80 percent) claystone (10 percent) and siltstone (10 percent). Mudstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2) with moderate brown (5YR3/4) limonitic stain; silty; two types of distinct horizontal burrows common, one less than 1 mm across and another between 3 and 5 mm across; irregular partings 2 to 5 mm thick; spheroidal weathering common. Claystone in beds up to 0.6 ft thick; indistinct, yellowish gray, horizontal burrows common. Siltstone in 10 beds up to 1.6 ft thick, mode is less than 0.2 ft. Covered from 39 to 43.5 ft below top.....	57.8	887.0
19.	Siltstone and very-fine-grained sandstone (60 percent) and mudstone with very minor claystone (40 percent). Siltstone and sandstone in single beds up to 2.2 ft thick and amalgamated beds up to 4.4 ft thick, mode is 0.1 ft, mean is 0.2 ft; amalgamation of beds common; Tbc and Tc Bouma sequences very common, Ta, Tab and Tabc sequences less common; abundant current formed sole markings include flute marks and groove casts with average orientation of 250°, blunt ends of		

	Thickness (feet) Unit	Cum.
flutes toward east. Mudstone is moderate olive brown (5Y4/4) weathers with moderate brown (5YR3/4) limonitic stain; silt laminae less than 1 mm thick rare; distinct horizontal burrows 3 to 5 mm across rare; partings 2 to 5 mm thick. Covered zone between 25.5 and 32.2 feet below top. Beds strike 134°, dip 32° to 40° E.....	88.9	829.2
18. Mudstone, with minor interlaminated claystone (85 percent) and siltstone (15 percent). Mudstone like unit 16. Intensive horizontal burrowing produces biolamination on the order of a few mm thick between 25 and 28 feet below top. Siltstone in beds up to 0.2 ft thick, mode is 0.1 ft; Tbc and Tc Bouma sequences common.....	40.5	740.3

NOTE: Fault with approximately 30 feet of displacement separates units 18 and 17. Beds correlatable across fault.

17. Siltstone (60 percent) and claystone (40 percent). Siltstone in eight beds, which range in thickness from 0.05 to 2.1 ft; Ta Bouma sequence in two thicker beds, Tc and Tcd common in thinner beds; straight or slightly curved organic sole markings common. Claystone is light olive brown (5Y5/6) weathers light olive gray (5Y5/2); silt-free to slightly silty; rare silt laminae less than 1.5 mm thick; partings 2 to 10 mm.....	10.4	699.8
16. Mudstone (85 percent) and siltstone (15 percent). Mudstone shows rare silt laminae less than 1.5 mm thick; distinct horizontal burrows 2 mm across common; irregular partings 2 to 5 mm thick; spheroidal weathering common. Siltstone in beds up to 0.4 ft thick, mode is 0.2 ft; current formed sole markings common, include groove casts oriented 238° and 240° and abundant flute marks at 17 ft below top oriented 236° and 238° with blunt ends toward east. Beds strike 134°, dip 26° SE.....	26.6	689.4

		Thickness (feet) Unit	Cum.
15.	Mudstone and minor claystone (95 percent) and siltstone (5 percent). Mudstone is olive gray (5Y3/2), weathers spheroidally to olive gray (5Y4/1) chips and blades; distinct horizontal burrows less than 4 mm across are common and are straight to curving, non-branched and weather moderate brown (5YR4/4); partings 4-10 mm thick. Claystone is intensely bioturbated with indistinct yellowish gray (5Y8/1) horizontal burrows. Siltstone in beds up to 0.5 ft thick, mode is 0.15 ft; Tc most common Bouma sequence, Ta sequences much less common.....	72.6	662.8
14.	Siltstone and very-fine-grained sandstone; olive gray (5Y4/1); in four beds which range in thickness from 0.3 to 2.3 ft; beds are amalgamated; Ta and Tb Bouma sequences; thickest bed shows bulbous sole markings which lack clear orientation.....	4.4	590.2
13.	Mudstone with minor clayshale and claystone (90 percent) and siltstone (10 percent). Mudstone is olive gray (5Y4/1); distinct horizontal burrows 3 to 5 mm across, non-branching, resemble Pteridichnites biseriatus (common between 31 and 41 feet below top); spheroidal weathering common. Claystone is light olive gray (5Y5/2); abundant indistinct yellowish gray burrows. Clayshale contains common silt laminae less than 1 mm thick. Siltstone is light olive gray (5Y5/2); beds up to 0.65 ft thick, mode is 0.15 ft; cross lamination very common; organic sole markings.....	83.0	585.8
12.	Clayshale (70 percent) and siltstone (30 percent). Clayshale is olive gray (5Y4/1); texturally laminated; silt-free to slightly silty; partings 3 mm thick. Siltstone in beds up to 0.7 ft thick, mode is 0.15 ft; Tc Bouma sequences are most common with few Tbc sequences; current-formed sole markings include flute marks oriented 254° and 263°		

		Thickness (feet) Unit	Cum.
	with blunt ends toward east and groove casts oriented 272° and 267°. Beds strike 139°, dip 36° SE.....	13.5	502.8
11.	Mudstone with minor clayshale and claystone (85 to 90 percent) and siltstone (10 to 15 percent). Mudstone like unit 9 except lacking burrows; weathers light olive gray (5Y5/2). Clayshale is light olive gray (5Y5/2); common silt laminae less than 1 mm thick, many show cross lamination. Claystone in upper 1.5 ft of unit is light olive gray (5Y6/1) to yellowish gray (5Y8/1), weathers light olive gray (5Y5/2) to subconchoidal chunks; abundant indistinct horizontal burrows; forms slight recess in outcrop. Siltstone like unit 9 in beds less than 0.3 ft thick; more abundant in upper 5 ft of unit.....	22.5	489.3
10.	Covered.....	6.2	466.8
9.	Mudshale (50 percent) and siltstone (50 percent). Mudshale contains parallel silt laminae less than 1 mm; partings 2 to 5 mm thick. Siltstone in 3 beds; 2.2 ft, 0.5 ft and 0.3 ft thick; Tab, Tb and Tbc Bouma sequences respectively; wavy, parallel partings 2 to 5 mm thick common.....	5.6	460.6
8.	"Back Creek Siltstone member" of Avary and Dennison (1978). Siltstone and very-fine-grained sandstone (70 percent) and clay-shale and mudstone (30 percent). Siltstone and sandstone are light olive gray (5Y5/2) to olive gray (5Y4/1); beds up to 5.1 ft thick, mode is less than 0.2 ft, mean is 0.4 ft; Tbc and Tc most common Bouma sequences, Ta, Tabc and Tac sequences less common; rippled upper surfaces common. Clayshale is light olive gray (5Y5/2); color and silt laminated; silt laminae less than 1 mm thick; slightly silty; partings 2 to 5 mm thick. Mudstone predominates between 35 and 30 ft below top; moderate		

		Thickness (feet) Unit	Cum.
	olive brown (5Y4/4) weathers light olive gray (5Y5/2) to olive gray (5Y4/1); irregular partings 3 to 10 mm thick.....	71.8	455.0
7.	Mudstone with less than 10 percent siltstone. Mudstone is light olive brown (5Y5/6) to moderate yellowish brown (10YR5/4), weathers spheroidally to light olive gray (5Y5/2) blades; abundant distinct horizontal burrows 3 to 5 mm across; rare silt laminae less than 1 mm thick. Siltstone in beds less than 0.2 ft thick, mode is 0.1 ft; Ta and Tb Bouma sequences common; carbonized wood fragments abundant along some bedding planes; organic sole markings common.....	37.4	383.2
6.	Siltstone (55 percent) and claystone with very minor mudstone (45 percent). Siltstone in seven beds, which range in thickness from 0.5 to 2.1 ft; Ta and Tc Bouma sequences common; rippled tops common. Claystone is silt-free to slightly silty; distinct, slightly curved horizontal burrows 3 to 4 mm across common; partings 1 cm thick.....	13.0	345.8
5.	Claystone (95 percent) and siltstone (5 percent). Claystone is dusky yellow (5Y6/4) to light olive brown (5Y5/6) weathers light olive gray (5Y5/2); like unit 7. Siltstone in two beds, 0.3 and 0.4 ft thick.....	17.8	332.8
4.	Covered.....	170.0	315.0
3.	Clayshale and mudshale (85 percent), claystone (10 percent) and siltstone (5 percent). Clayshale, mudshale and claystone are moderate olive brown (5Y5/4); shales contain common silt laminae; partings 1 to 3 mm thick. Claystone has subconchoidal partings 3 to 10 mm thick. Siltstone in beds less than 0.2 ft thick; Tbc and Tc Bouma sequences common.....	55.0	145.0
2.	Covered.....	67.0	90.0

	Thickness (feet) Unit	Cum.
1. Mudshale (80 percent) and siltstone (20 percent). Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); texturally laminated; rare silt laminae less than 1 mm thick; partings 2 to 4 mm thick; shale becomes platy in upper half of unit. Siltstones in beds less than 0.15 ft thick; Tc Bouma sequences common.....	23.0	23.0
Total Brallier Formation.....	1385.4	

SECTION 15

Rimel Section

Incomplete section of Brallier Formation exposed in roadcut on northeast side of West Virginia Route 39, 0.1 mile west of its junction with West Virginia Route 92 at Rimel, Pocahontas County, Minnehaha Springs quadrangle, West Virginia (591750 meters East, 4220000 meters North, Universal Transverse Mercator grid). Section is in upper one-third of Brallier Formation. Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard and Robert J. Lundegard, November 27, 1977.

Brallier Formation (incomplete):	Thickness (feet) Unit	Cum.
9. Siltstone (55 percent) in beds up to 0.3 ft thick, modal bed thickness is 0.2 ft, with interbeds of mudshale (45 percent) predominantly less than 0.15 ft thick. Siltstone is medium gray (N5), weathers olive gray (5Y4/1); bed thickness is very uniform, beds predominantly show Tc- Bouma sequences, flat, sharp bases and rippled top surfaces; wood fragments less than 1 cm long on some bedding planes; a few of the thicker beds have flute and groove molds; 0.2 ft thick bed at 6 ft above base of unit has flute molds trending 243° with blunt ends towards east. Mudshale is olive gray (5Y4/1); shows textural lamination; numerous silt		

		Thickness (feet) Unit	Cum.
	laminae up to 1 cm thick; parting is 2 to 4 mm thick.....	22.0	107.4
8.	Siltstone (75 percent) in beds up to 1.1 ft thick, modal bed thickness is 0.1 ft, with interbeds of mudshale (25 percent) predominantly less than 0.2 ft thick. Unit 8 is distinguished from unit 9 by presence of several beds greater than 0.3 ft thick. Siltstone is medium gray (N5), weathers olive gray (5Y4/1); 75 percent of beds show Tc- Bouma sequences; horizontal burrows are common on top surface of beds; 0.5 ft thick bed 2.4 ft above base has abundant flute molds trending 278° with blunt end towards east. Mudshale is medium gray (N5), weathers olive gray (5Y4/1); shows textural lamination; parting is 1 to 4 mm thick.....	19.8	85.4
7.	Clayshale (60 percent) with beds of siltstone (40 percent) up to 0.25 ft thick. Clayshale is medium gray (N5) to medium dark gray (N4); shows textural lamination; parting is 2 to 4 mm thick. Siltstone beds show Tc- Bouma sequences.....	5.1	65.6
6.	Siltstone, coarse-grained, to sandstone, very-fine-grained (85 percent) in beds less than 0.1 ft thick to 0.3 ft thick, with interbeds of clayshale (15 percent). Siltstone and sandstone beds show Tc- Bouma sequences. Clayshale is olive gray (5Y3/2); shows textural lamination; slightly silty.....	1.9	60.5
5.	Clayshale, olive gray (5Y3/2); shows textural lamination; slightly silty; parting is 3 mm thick.....	1.7	58.6
4.	Siltstone and very-fine-grained sandstone (75 percent) in beds up to 1.0 ft thick, with interbeds of clayshale as in unit 5 (25 percent) less than 0.3 ft thick. Eight siltstone beds greater than 0.4 ft thick are distinctive of unit 4; these thicker beds show Ta- or Tb- Bouma sequences. Tiny		

		Thickness (feet) Unit	Cum.
	carbonized wood fragments are common in siltstone beds; horizontal burrows are common on top surfaces of beds; 1.0 ft thick bed at 6.7 ft below top of unit shows Tbc Bouma sequence and abundant flute and groove molds trending 283°. Minor beds of dark gray (N3) shale showing textural lamination.	18.9	56.9
3.	Clayshale (75 percent) with beds of siltstone (25 percent) up to 0.45 ft thick, predominantly less than 0.1 ft thick. Clayshale is olive gray (5Y3/2); locally has a light brown (5YR5/6) weathering stain; shows textural lamination. Siltstone beds predominantly show Tc- Bouma sequences and rippled upper surfaces; current-formed sole markings and hypichnial ridges are common; 0.2 ft thick bed at 1.8 ft above base of unit has bounce molds trending 247°; 0.45 ft thick bed at 3.5 ft below top of unit has groove molds trending 295°.....	17.5	38.0
2.	Siltstone (65 to 85 percent) in beds up to 1.0 ft thick, modal bed thickness is 0.15 ft, with interbeds of clayshale to mudshale (15 to 35 percent). Siltstone is medium gray (N5), weathers light olive gray (5Y3/2); beds predominantly show Tc- Bouma sequences, flat, sharp bases and rippled top surfaces; two beds, 1.0 ft and 0.8 ft thick show Tbc- Bouma sequences at 4.0 ft and 11.2 ft above base of unit, respectively; burrows are common and of 3 types; hypichnial ridges, horizontal burrows on top surfaces of beds, and high-angle burrows penetrating beds from the top; these latter burrows are non-branching, straight to slightly curved, 5 to 10 mm wide, and either silt- or clay-filled. Shale is olive gray (5Y3/2); shows textural lamination; locally silty; horizontal burrows less than 5 mm wide are common; parting is 3 to 5 mm thick.....	15.8	20.5
1.	Clayshale (90 percent) with beds of siltstone (10 percent) less than 0.1 ft thick. Clay-		

	Thickness (feet) Unit	Cum.
shale is olive black (5Y2/1), weathers olive gray (5Y4/1); shows textural lamination; slightly silty; parting is 3 mm thick. Siltstone is medium gray (N5); beds show Tc- Bouma sequences and rippled top surfaces.	4.7	4.7
Total Brallier Formation (incomplete)..	107.4	

SECTION 16

Minnehaha Springs Section

Incomplete section of Brallier Formation exposed in roadcut along northeast side of West Virginia Route 39, 1.3 miles southeast of Minnehaha Springs, Pocahontas County, Minnehaha Springs quadrangle, West Virginia (589200 meters East, 4222500 meters North, Universal Transverse Mercator Grid). Bedding strikes 48 degrees northeast, and dips 37 degrees southeast. Base of section is estimated to be less than 500 feet above the base of the Brallier Formation. Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard and Robert J. Lundegard, November 26, 1977.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
7. Mudshale (75 percent) with beds of siltstone (25 percent) up to 0.35 ft thick, predominantly less than 0.15 ft thick. Siltstone decreases in abundance upward. Mudshale is olive gray (5Y4/1) to medium gray (N5), weathers olive gray (5Y4/1) to grayish red (5R4/2); reddish weathering is prominent in upper 25 ft of unit; shows textural lamination; silt laminae 5 to 10 mm thick are common. Siltstone beds have flat sharp bases, and show predominantly Tc- Bouma sequences; top surfaces of beds are commonly rippled and show horizontal burrows.....	37.0	135.0
6. Clayshale (55 percent) with beds of siltstone (45 percent) up to 0.65 ft thick, predominantly less than 0.1 ft to 0.3 ft		

		Thickness (feet) Unit	Cum.
	thick. Clayshale is medium gray (N5), weathers olive gray (5Y4/1); shows textural lamination; a few silt laminae; distinct horizontal burrows. Siltstone is medium gray (N5); micaceous; beds predominantly show Tc- Bouma sequences; top surfaces of beds are commonly rippled and show horizontal burrows.....	11.0	98.0
5.	Clayshale as in unit 6 (85 percent) with beds of siltstone (15 percent) up to 0.25 ft thick. Siltstone beds predominantly show Tc- Bouma sequences; top surfaces of beds are commonly rippled and show horizontal burrows.....	11.2	87.0
4.	Siltstone to very-fine-grained sandstone (75 percent) in beds 0.1 ft to 2.2 ft thick, no distinct modal bed thickness, with interbeds of clayshale to mudshale (25 percent). Unit 4 was described in bed by bed detail. Siltstone and sandstone are medium gray (N5), weather light olive gray (5Y6/1); micaceous; tiny wood fragments are common; clay galls are common in thicker beds; beds have sharply defined bases and slightly gradational tops; 50 percent of beds show Ta- Bouma sequences, 32 percent show Tb- Bouma sequences, 18 percent show Tc- Bouma sequences; the unit ABC proximity index (Walker, 1967) is 66 percent; beds commonly have rippled top surfaces. Shale is medium dark gray (N4), weathers olive gray (5Y4/1); shows textural lamination; a few silt laminae; horizontal burrows up to 5 mm wide.....	24.4	75.8
3.	Mudshale (98 percent) with beds of siltstone (2 percent) up to 0.35 ft thick, predominantly less than 0.1 ft thick. Mudshale is olive gray (5Y4/1); shows weak textural lamination; horizontal burrows up to 5 mm wide; parting is 1 to 5 mm thick. Siltstone beds predominantly show Tc- Bouma sequences and rippled top surfaces.....	33.6	51.4

	Thickness (feet) Unit	Cum.
2. Siltstone (65 percent), 3 beds, each 0.6 ft thick, with interbeds of clayshale (35 percent). Siltstone is medium gray (N5), weathers light olive gray (5Y6/1). Clayshale is olive gray (5Y4/1); shows textural lamination.....	2.8	17.8
1. Mudshale to clayshale with a very few beds of siltstone less than 0.15 ft thick. Shale is olive gray (5Y4/1); shows weak textural lamination; finely micaceous; non-branching horizontal burrows up to 5 mm wide are very common. Siltstone is light olive gray (5Y6/1) to olive gray (5Y4/1); beds predominantly show Tc- Bouma sequences and rippled top surfaces; a few beds show sinusoidal lamination.....	15.0	15.0
Total Brallier Formation (incomplete)..	135.0	

SECTION 17

Clifton Forge Section

Incomplete section of Brallier Formation exposed in roadcut on North side of U.S. Highway 60, approximately 0.3 mile east of its junction with Virginia Highway 42 in Rockbridge County, Clifton Forge quadrangle (609200 meters ast, 4187200 meters orth, Universal Transverse Mercator grid). Section is of a thickly bedded siltstone bundle. Bedding strikes 44 degrees east and dips 55 degrees southeast. Section measured and described using Jacob's staff, Abney level, and tape by Paul D. Lundegard, September 1, 1977.

Brallier Formation (incomplete):	Thickness (feet) Unit	Cum.
2. Clayshale to mudshale (80 percent) with beds of siltstone (20 percent) up to 0.15 ft thick. Siltstone decreases in abundance upward. Shale weathers light olive gray (5Y5/2); shows textural lamination; silty in places; some horizontal burrows less than		

		Thickness (feet) Unit	Cum.
	4 mm wide; parting is 3 to 5 mm thick. Siltstone weathers light olive gray (5Y5/2); beds predominantly show Tc- Bouma sequences.....	14.0	54.0
1.	Siltstone and very-fine-grained sandstone (70 percent) in beds 0.1 ft to 3.5 ft thick, 40 percent of beds are greater than 0.5 ft thick, modal bed thickness is 0.3 to 0.5 ft; interbeds are shale as in unit 2 (30 percent). Unit 1 was measured and described in bed by bed detail. Siltstone and sandstone weather light olive gray (5Y5/2); base of beds are sharp and flat; tops of beds are sharp or gradational; a few beds are graded; approximately 60 percent of beds show Ta- Bouma sequences; beds with rippled top surfaces are common; wood fragments are common; micaceous. Unit 1 forms a resistant protrusion. Using Jacob's staff and Abney level, the base of unit 1 was estimated to be less than 350 ft above the top of the Millboro Shale.....	40.0	40.0
	Total Brallier Formation (incomplete)..	54.0	

SECTION 18

Cloyds Mountain Section

One of the best and most nearly complete sections of the Brallier Formation in southwest Virginia, exposed in roadcuts along Virginia Highway 100, Pulaski County, Staffordsville quadrangle, Virginia. Lower one-third of section is unusually well exposed. Base of section is at shale pit behind French's Chapel at base of Cloyds Mountain (523800 meters East, 4116300 meters North, Universal Transverse Mercator grid). Section continues generally southward up Cloyds Mountain to 0.1 mile north of its crest. Section was measured, described and sampled using Jacob's staff, Abney level, surveying altimeter and tape by Paul Lundegard and Neil Samuels, on August 26, and 27, 1977, by Paul Lundegard on December 18 and 19, 1977, January 1, 2, and 3, 1978, and August 28, 29, and 30, 1978. Radioactivity profile

was measured using scintillometer by Paul Lundegard and Neil Samuels on June 4 and 5, 1978.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
"Chemung" Formation (incomplete):		
92. Sandstone, very-fine-grained to fine-grained, dusky yellow (5Y6/4), weathers light olive gray (5Y6/1); beds 0.8 ft to 2.5 ft thick; plane laminated; fossiliferous streaks up to 0.3 ft thick; fossils include Spirifer sp. and crinoid columnals. Unit 92 is directly across highway from "Watch for Fallen Rocks" sign.....	21.0	3840.0
91. Mostly covered with small exposures of olive gray mudstone.....	11.0	3819.0
90. Sandstone, very-fine-grained to fine-grained, dusky yellow (5Y6/4), weathers light olive gray (5Y6/1), beds 0.7 ft to 1.5 ft thick; plane laminated; several highly fossiliferous layers with Spirifer sp., Chonetes sp., and crinoid columnals all common; many whole brachiopod valves are at an angle to bedding. Unit 90 is very resistant.....	18.0	3810.5
89. Sandstone, very-fine-grained (70 percent), in beds 0.1 ft to 3.0 ft thick, modal bed thickness is 0.9 ft, with interbeds of mudstone (30 percent). Sandstone beds are predominantly plane laminated; several lensoid beds in upper half of unit; several beds weather spheroidally, probably because of convolute lamination; fossiliferous streaks and layers very common, especially at the base of beds; crinoid columnals some of which are articulated are the most abundant fossil, Camarotoechia sp., Spirifer sp., and Chonetes sp. brachiopods are also present. Mudstone is olive gray (5Y4/1) and has hackly parting...	40.0	3792.5
88. Mudstone (60 to 70 percent) with beds of very-fine-grained sandstone (30 to 40 percent) 0.4 ft to 2.0 ft thick, modal bed thickness is 0.7 ft. Mudstone is olive gray (5Y3/2), weathers light olive gray (5Y5/2); resistant, very silty, weathers to		

		Thickness (feet) Unit	Cum.
	hackly chips. Sandstone beds are plane laminated; a few beds weather spheroidally probably because of convolute lamination; fossiliferous streaks containing crinoid columnals, and Camarotoechia sp., and Chonetes sp. brachiopods are common, especially at base of beds. Minor shear zone in middle of unit 88.....	79.5	3752.5
87.	Mudstone as in unit 88 (90 percent) with beds of siltstone (10 percent) 0.1 to 0.2 ft thick.....	21.0	3673.0
86.	Sandstone, very-fine-grained (50 percent), in beds 0.3 ft to 1.7 ft thick, with interbeds of mudstone as in unit 88 (50 percent). Sandstone beds show plane lamination or low-angle crossbedding; a few fossiliferous streaks containing crinoid columnals and brachiopod shell fragments....	6.2	3652.0
85.	Sandstone, very-fine-grained (95 percent), in beds 0.5 ft to 1.5 ft thick, with minor interbeds of mudstone in unit 88 (5 percent). A resistant unit. Sandstone beds are plane laminated; a few fossiliferous streaks containing crinoid columnals and very few Spirifer sp. Unit 85 is described at sharp bend in highway 0.15 mile north of crest of Cloyd's Mountain.....	7.3	3645.8
	Total "Chemung" Formation (incomplete).	204.0	

Brallier Formation:

84.	Siltstone, coarse-grained, and sandstone, very-fine-grained (60 to 70 percent), in beds 0.4 ft to 2.0 ft thick with interbeds of mudstone (30 to 40 percent). Siltstone and sandstone are medium gray (N5), weather light olive gray (5Y5/2); beds are indistinct from mudstone interbeds; beds are plane laminated. Mudstone is olive gray (5Y4/1) and very silty. Unit 84 is described across highway from "Maximum Safe Speed 25" sign...	13.1	3638.5

		Thickness (feet) Unit	Cum.
83.	Covered.....	22.8	3625.4
82.	Siltstone, coarse-grained, and sandstone, very-fine-grained (50 percent), in beds 0.3 ft to 1.3 ft thick, modal bed thickness is 0.5 ft, with interbeds of mudstone as in unit 84 (50 percent). Fossiliferous streaks and lenses are common in siltstone and sandstone beds; crinoid columnals common, Camarotoechia sp., Spirifer sp. brachiopods, and Modiola (?) pelecypods. Two intervals of mudstone without coarse clastic beds, 5.9 and 4.5 ft thick, at 9 and 32 ft above base of unit, respectively. Top of unit 82 is at sharp bend in highway.....	50.6	3602.6
81.	Mudstone (95 percent) with a few beds of siltstone (5 percent) 0.15 to 0.8 ft thick in lower half of unit. Mudstone is olive gray (5Y5/2), weathers to small hackly chips. Siltstone beds are predominantly plane laminated; a few fossiliferous streaks containing crinoid columnals and brachiopod fragments.....	31.6	3552.0
80.	Siltstone and very-fine-grained sandstone (75 percent) in beds 0.4 ft to 1.3 ft thick with interbeds of mudstone as in unit 81 (25 percent). Siltstone and sandstone beds are fossiliferous; Camarotoechia sp. and crinoid columnals concentrated in layers concordant with bedding; wood fragments; siltstone bed 1.3 ft thick at top of unit is crossbedded and highly fossiliferous in basal 0.5 ft.....	7.4	3520.4
79.	Mudstone as in unit 81 (90 to 95 percent) with beds of siltstone (5 to 10 percent) 0.1 to 0.4 ft thick.....	16.0	3513.0
78.	Siltstone, coarse-grained (50 to 60 percent), in beds up to 1.0 ft thick, beds greater than 0.4 ft thick are very common, with interbeds of mudstone (40 to 50 percent). Siltstone is light olive gray (5Y5/2); beds		

		Thickness (feet) Unit	Cum.
	are predominantly structureless or plane laminated; beds indistinct in places; 1.0 ft thick bed with low-angle crossbedding at 43 ft above base of unit; 0.4 ft thick bed with fine groove molds trending 254° at 28 ft above base of unit; a few beds are fossiliferous; fossils include crinoid columnals, Fenestellina sp. bryozoans, and Camarotoechia sp., Spirifer sp. brachiopods. Mudstone is olive gray (5Y4/1); very silty; nearly as resistant as siltstone; minor mudshale with textural lamination throughout unit.....	161.3	3497.0
77.	Covered.....	22.2	3335.7
76.	Mudstone and minor claystone (85 percent) with beds of siltstone (15 percent) up to 0.3 ft thick, modal bed thickness is 0.15 ft Mudstone and claystone are olive gray (5Y4/1) to light olive gray (5Y5/2); a few distinct horizontal burrows, 3 to 5 mm wide and weathering moderate brown (5YR4/4); hackly parting 5 to 10 mm thick. Siltstone beds are concentrated in lower 8 ft of unit; Tc- and Tb- Bouma sequences predominate. Top of unit is at sharp bend in highway.....	23.4	3313.5
75.	Mudstone as in unit 76 (50 to 70 percent) with beds of siltstone (30 to 50 percent) up to 1.2 ft thick, modal bed thickness is 0.15 ft. Several siltstone beds with sole markings; groove mold trends 268° at 8.2 ft below top of unit; middle 7 ft of unit is thinner bedded and 30 percent siltstone.....	17.6	3290.1
74.	Mudstone as in unit 76 (60 percent) and claystone (30 percent), with beds of siltstone (10 percent) up to 0.9 ft thick, modal bed thickness is 0.1 ft. Mudstone and claystone are alike except for disseminated silt content; some spheroidal weathering in lower 12 ft of unit; pelecypod sampled at 7 ft above base of unit.		

		Thickness (feet) Unit	Cum.
	Siltstone beds greater than 0.3 ft thick show Ta- and Tb- Bouma sequences; beds less than 0.3 ft thick show Tc- and Tb- Bouma sequences.....	73.3	3272.5
73.	Siltstone (40 to 60 percent) in beds up to 1.2 ft thick, with interbeds of claystone and mudstone (40 to 60 percent); modal siltstone bed thickness is generally less than 0.15 ft but up to 0.45 in some 5 ft intervals. Siltstone is light olive gray (5Y6/1); beds are even, persistent, and sharply defined; internal structures are difficult to see because of intense weathering; beds greater than 0.3 ft thick show Ta- and Tb- Bouma sequences, beds less than 0.15 ft thick show Tc- and Tb- Bouma sequences; convolute lamination in several beds; flute molds common, mean trend of 265°. Claystone is light olive brown (5Y5/6), weathers light olive gray (5Y5/2); becomes mudstone upward; some indistinct horizontal bioturbation, weathering yellowish gray (5Y8/1); minor shale with textural lamination and a few silt laminae less than 1 mm thick. Base of unit 73 at "Maximum Safe Speed 25" sign..	96.7	3199.2
72.	Covered. Few resistant siltstone beds, probably less than 10 percent. Sanitary landfill behind low hill which parallels highway.....	84.0	3102.5
71.	Claystone (90 percent) with beds of siltstone (10 percent) up to 1.2 ft thick, modal bed thickness is 0.1 to 0.15 ft. Claystone is moderately bioturbated; unbioturbated portions are dark gray (N3) and weather medium gray (N5); bioturbated portions are yellowish gray (5Y8/1) to medium light gray (N6) and weather grayish orange (10YR7/4); burrowing is indistinct and horizontal; individual burrows appear to be less than 2 mm wide; some irregular biolamination and streaks; weathers to		

		Thickness (feet) Unit	Cum.
	chunks and small flakes; minor light olive brown (5Y5/6) to light olive gray (5Y5/2) claystone and mudstone. Two highly fractured siltstone beds at top of unit, 1.2 ft and 0.8 ft thick, respectively.....	36.0	3018.5
70.	Covered. Several resistant beds of siltstone.....	5.0	2982.5
69.	Claystone (50 to 60 percent) with beds of siltstone (40 to 50 percent) up to 0.7 ft thick, modal bed thickness is 0.3 ft. Claystone is yellowish gray (5Y8/1); probably bioturbated as in unit 71. Siltstone is highly weathered; yellowish gray (5Y8/1) on weathered surface. Unit 69 forms rounded protrusion on outcrop.....	16.6	2977.5
68.	Claystone as in unit 71 (90 percent) with beds of siltstone (10 percent) up to 1.0 ft thick, modal bed thickness is 0.15 ft. Claystone becomes darker and less bioturbated upward; faint textural lamination and rare silt laminae less than 2 mm thick where unbioturbated.....	15.4	2960.9
67.	Claystone as in unit 71 (50 to 60 percent) with beds of siltstone (40 to 50 percent) up to 0.6 ft thick, modal bed thickness is 0.25 ft. Siltstone content is approximately 75 percent in 5 ft thick zone 5 ft above base of unit. Unit 67 forms a slight protrusion.....	19.0	2945.5
66.	Claystone as in unit 71 with a very few siltstone beds up to 0.25 ft thick. A few grouped silt laminae up to 3 mm thick in claystone.....	11.5	2926.5
65.	Claystone as in unit 71 (95 percent) with 4 beds of siltstone (5 percent) 0.3 to 0.6 ft thick. Base of unit 65 is exposed in drainage ditch along chainlink fence, uphill from entrance to sanitary landfill.....	42.5	2915.0

		Thickness (feet) Unit	Cum.
64.	Covered. Thickness estimated from map locations of outcrops, strike and dip data, and altitude data obtained with a surveying altimeter accurate to ± 3 ft.....	70.0	2872.5
63.	Clayshale to mudshale, dark gray (N3) in lower 1.0 ft, medium dark gray (N4) in remainder, weathers medium dark gray (N4); weak textural lamination; very finely micaceous; parting is 3 to 10 mm thick; a few 1 to 2 cm thick siltstone layers gradational with surrounding shale and laminated or cross-laminated. Unit 63 is described at apex of hairpin turn in highway.....	19.6	2802.5
62.	Siltstone, coarse-grained, and sandstone, very-fine-grained (60 percent), in beds up to 1.4 ft thick, modal bed thickness is 0.5 ft with interbeds of mudshale (40 percent). Siltstone and sandstone are medium gray (N5) to medium dark gray (N4); beds mainly show Ta- Bouma sequences, beds less than 0.1 ft thick show Tc- Bouma sequences; upper parts of a few beds have parallel undulatory lamination with wavelengths of 30 to 40 cm and amplitudes of 3 to 5 cm. Mudshale is grayish black (N2), weathers dark gray (N3); shows textural lamination; a few silt laminae less than 1 mm thick, parting is 1 to 3 mm thick; blackish red (5R2/2) iron stain on parting surfaces; weathers to brittle platy chips.....	9.1	2782.9
61.	Clayshale or claystone. Prominent lateral changes in nature of unit 61; clayshale at road level, changing to predominantly bioturbated claystone at top of outcrop. Clayshale is grayish black (N2) to black (N1), weathers medium dark gray (N3) to grayish black (N2); strong textural lamination; finely micaceous; parting is 1 to 3 mm thick; finely divided pyrite and iridescent grayish black (5R2/2) iron stain on parting		

		Thickness (feet) Unit	Cum.
	surfaces; weathers to brittle, platy chips, lower 3.0 ft of unit is slightly lighter in color and silty. Claystone is medium dark gray (N4), weathers medium gray (N5) to medium dark gray (N4); weakly to strongly bioturbated; bioturbated portions weather yellowish gray (5Y8/1); individual burrows are less than 3 mm wide and predominantly horizontal; burrows have diffuse boundaries; some zones up to 2 cm thick are completely bioturbated; these appear as yellowish gray, discontinuous laminae or beds.....	12.3	2773.8
60.	Claystone (90 percent) with beds of siltstone (10 percent) up to 0.35 ft thick, modal bed thickness is 0.1 ft. Claystone is medium dark gray (N4) to dark gray (N3), weathers medium gray (N5); locally slightly silty; finely micaceous; parting is 5 mm thick; brittle. Siltstone is medium gray (N5); beds show Tc- Bouma sequences; finely micaceous.....	5.7	2761.5
59.	Siltstone and very-fine-grained sandstone (60 percent) in beds 1 cm to 0.7 ft thick, modal bed thickness is 0.25 ft, with interbeds of clayshale (40 percent). Siltstone and sandstone are medium gray (N5) and micaceous; 50 percent of beds are cross-laminated; several beds show undulatory lamination with wavelengths of approximately 40 cm; one crossbedded sandstone bed 0.5 ft thick near base of unit; a few molds of brachiopods and crinoid columnals. Clayshale is dark gray (N3), weathers medium dark gray (N4); weak textural lamination; locally slightly silty; parting is 3 to 5 mm thick; brittle.....	7.3	2755.8
58.	Clayshale (90 percent) with beds of siltstone and very-fine-grained sandstone (10 percent) up to 0.25 ft thick, modal bed thickness is less than 0.1 ft. Clayshale is medium dark gray (N4), shows textural lamination; locally slightly silty;		

		Thickness (feet) Unit	Cum.
	finely micaceous; parting is 2 to 5 mm thick. Siltstone and sandstone are medium gray (N5); beds show Tc- and a few Tb- Bouma sequences, top surfaces of beds are rippled; one bed with fragments of brachiopod shells and crinoid columnals; abundant groove molds at 2.4 ft above base of unit have mean trend of 268°.....	10.7	2748.5
57.	Siltstone, coarse-grained, and sandstone, very-fine-grained (75 percent) in beds up to 0.8 ft thick, modal bed thickness is 0.25 ft, with interbeds of clayshale (25 percent) less than 0.2 ft thick. Siltstone and sandstone are medium gray (N5); thin fossiliferous lenses with Spirifer sp. most abundant; sole markings trend 274° at base of unit. Clayshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); weak textural lamination; tiny black shreds of organic matter, parting is 3 to 5 mm thick..	6.3	2737.8
56.	Clayshale (75 percent) with beds of siltstone (25 percent) 1 cm to 0.3 ft thick. Clayshale is olive gray (5Y4/1) weathers light olive gray (5Y5/2); weak textural lamination; tiny black shreds of organic matter; parting is 2 to 5 mm thick; weathers to brittle, platy chips. Siltstone is olive gray (5Y4/1) to medium gray (N5); finely micaceous; beds show cross-lamination to sinusoidal lamination, abundant groove molds show a mean trend of 278°.....	8.0	2731.5
55.	Siltstone and very-fine-grained sandstone (80 percent) in beds up to 2.0 ft thick, with interbeds of clayshale (20 percent) less than 0.3 ft thick. Siltstone and sandstone are medium gray (N5) and micaceous; tiny black shreds of organic matter; Spirifer sp., pelecypods (?), and crinoid columnals are common; beds 0.6 ft to 2.0 ft thick are plane laminated or crossbedded; beds less than 0.2 ft thick are cross-laminated or		

		Thickness (feet) Unit	Cum.
	plane laminated; trough crossbedding in the upper parts of several beds, strata thicken from the crests towards the troughs. Clay-shale is medium dark gray (N4) to olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; tiny black shreds of organic matter; parting is 3 mm thick.....	8.0	2723.5
54.	Siltstone, coarse-grained, and sandstone, very-fine-grained in 5 beds 1.0 ft to 2.5 ft thick, separated by shale partings. Siltstone and sandstone are medium dark gray (N4), weather light olive gray (5Y5/2); finely micaceous; trough crossbedding features 1 to 2 m across as in unit 55, trough axis in middle of unit trends 080°-260°, beds otherwise show plane lamination or lamination inclined at low angle to bedding; carbonized wood fragments up to 5 mm long; fossils include Spirifer sp., Schizobolus sp. and Rhipidomella vanuxemi (Hall), and crinoid columnals; fossils are weakly oriented, generally unbroken and disarticulated; occur as concentrations at the base of beds, as lenses within beds, and disseminated in beds.....	8.7	2715.5
53.	Siltstone to fine-grained sandstone (90 percent) in beds 0.2 ft to 1.4 ft thick, with interbeds of clayshale (10 percent) less than 0.25 ft thick. Siltstone and sandstone are medium gray (N5), weather light olive gray (5Y5/2); finely micaceous; carbonized wood fragments 1 to 4 mm long; beds are dominantly even but several thicker beds pinch and swell; trough crossbedding as in unit 55; two beds 0.3 ft thick with undulatory top surfaces and form concordant lamination, at 9.0 ft above base of unit; wavelengths of undulations are approximately 45 cm, two crests trend 250° and 270°; wood fragments at 4.0 ft		

		Thickness (feet) Unit	Cum.
	above base of unit trend 277°; low relief flute molds at 19.2 ft above base of unit trend 277°. Clayshale is dark gray (N3), weathers medium dark gray (N4); shows textural lamination; silt-free; parting is 1 to 2 mm thick. Bed of claystone, 0.1 ft thick, at 8.7 ft above base of unit; yellowish gray (5Y8/1); plastic and sticky when wet; forms recess in outcrop.....	25.3	2706.8
52.	Siltstone and very-fine-grained sandstone (80 percent) in beds up to 1.0 ft thick, modal bed thickness is 0.3 ft, with interbeds of mudshale (20 percent) less than 0.15 ft thick. Siltstone and sandstone are medium gray (N5) to light olive gray (5Y6/1), weathers light olive gray (5Y5/2); micaceous; evenly bedded; less than 5 percent of beds have rippled top surfaces; beds greater than 0.3 ft thick show predominantly Ta- Bouma sequences; a few beds show low-angle inclined lamination; remainder of beds are plane laminated or cross-laminated; several beds are fossiliferous; fossils include unbroken and unabraded Camarotoechia sp. and Spirifer sp. in all orientations; a few clay-filled vertical burrows less than 1 cm wide. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; parting is 3 to 5 mm thick. Unit 52 is gradational with units 53 and 51 in abundance of coarse clastic beds and bed thickness.....	30.4	2681.5
51.	Mudstone (65 percent), minor claystone and clayshale (5 percent) with beds of siltstone to very-fine-grained sandstone (30 percent) up to 1.4 ft thick, modal bed thickness is 0.7 ft. Mudstone and claystone are dark gray (N3) to olive gray (5Y4/1); finely micaceous; tiny black shreds of organic matter; a few yellowish gray (5Y8/1) burrow mottles; irregular parting 5 to 20 mm thick;		

		Thickness (feet) Unit	Cum.
	weathers to subequidimensional chunks; clayshale resembles claystone but shows textural lamination. Siltstone and sandstone are medium gray (N5), weather light olive gray (5Y5/2); Ta- Bouma sequences predominate; content grading in some beds...	40.0	2651.1
50.	Claystone (60 percent) and 3 prominent beds of coarse-grained siltstone, each 0.7 ft thick. Claystone is medium gray (N5) to dark gray (N3), weathers olive gray (5Y4/1); slightly silty; a few yellowish gray (5Y8/1) burrow mottles. In ascending order, unit 50 consists of a siltstone bed 0.7 ft thick, structureless, inversely graded, groove molds trend 262° and 270°; 1.1 ft of claystone as above; a siltstone bed 0.7 ft thick, cross-laminated in upper 0.15 ft, structureless at base, sole markings; 1.1 ft of claystone as above; a siltstone bed 0.7 ft thick, basal contact is sharp and top contact is gradational, plane laminated and inversely graded, each laminae is thicker and coarser than the one below, groove molds trend 276°. Beds gently folded.....	4.8	2611.1
49.	Mudstone, claystone and minor clayshale (85 percent) with beds of siltstone and very-fine-grained sandstone (15 percent) up to 0.6 ft thick, modal bed thickness is 0.2 ft. Mudstone in lower two-thirds of unit; claystone and clayshale in upper third of unit. Mudstone and claystone are olive gray (5Y4/1) to medium gray (N5), weather light olive gray (5Y5/2); very few silt laminae less than 2 mm thick; upper 27.8 ft of unit is weakly bioturbated; burrow mottles weather light gray (N7) to yellowish gray (5Y8/1); burrows are horizontal; moderate brown (5YR4/4) spores (?) on bedding planes; clayshale resembles claystone but shows textural lamination. Siltstone and sandstone are medium gray (N5); finely		

		Thickness (feet) Unit	Cum.
	micaceous; beds less than 0.2 ft thick show Tc- Bouma sequences; thicker beds show Tc- or Tbc- Bouma sequences; flute molds trend 282° to 302°. Beds are gently folded in upper half of unit.....	78.8	2606.3
48.	Covered. Culvert under road and "Pavement Narrows" sign in middle of unit 48.....	45.0	2527.5

NOTE: Units 47 through 30 are described at long continuous roadcut on east side of Virginia Highway 100. High-voltage power lines parallel road on hill above outcrop.

47.	Mudstone (60 to 80 percent) with beds of siltstone (20 to 40 percent) up to 0.8 ft thick, predominantly less than 0.15 ft thick. Mudstone is light olive gray (5Y5/2); poorly bedded; irregular parting 5 mm thick. Siltstone beds have flat, sharp bases and undulatory, rippled top surfaces; Tc- or Tbc- Bouma sequences; very few crinoid columnals.....	54.2	2482.5
46.	Siltstone and very-fine-grained sandstone (60 percent) in beds up to 1.0 ft thick, modal bed thickness is 0.25 ft, with interbeds of mudstone (40 percent). Siltstone and sandstone are olive gray (5Y4/1); micaceous; laminated to cross-laminated; sinusoidal lamination grades upward into cross-lamination in a few beds; 0.9 ft thick bed at 9.5 ft above base shows convolute lamination. Mudstone is olive gray (5Y4/1) to medium gray (N5), weathers light olive gray (5Y5/2); hackly parting 3 to 5 mm thick; very silty. Small, high angle fault of uncertain displacement in upper part of unit.....	21.3	2428.3
45.	Clayshale to mudshale (50 to 60 percent) with beds of siltstone (40 to 50 percent) up to 0.9 ft thick, 90 percent of beds are less than 0.25 ft thick. Siltstone ranges from 20 to 70 percent in some five ft intervals. Shale is dark greenish gray (5GY4/1) to olive gray (5Y4/1), weathers moderate brown		

		Thickness (feet) Unit	Cum.
	(5YR3/4); shows textural lamination; locally silty; parting is 1 to 3 mm thick; few moderate brown (5YR4/4) spores (?) on bedding planes. Siltstone beds less than 0.2 ft thick are laminated or cross-laminated and have rippled top surfaces; micaceous; some woody fragments along bedding planes. "Trucks Use Right Lane" sign is across highway from top of unit.....	87.8	2407.0
44.	Clayshale as in unit 45 (95 percent) with minor beds of siltstone (5 percent) up to 0.45 ft thick, 90 percent of beds are less than 0.1 ft thick. Siltstone is medium gray (N5), weathers light olive gray (5Y5/2); beds are predominantly cross-laminated, and have flat, sharp bases and rippled top surfaces; a few carbonized wood fragments.....	11.7	2319.2
43.	Siltstone (60 percent, but variable over small intervals) in beds up to 1.1 ft thick, 90 percent of beds are less than 0.2 ft thick, with interbeds of clayshale (40 percent). Siltstone is medium gray (N5), weathers olive gray (5Y4/1); micaceous; evenly bedded; thicker beds show Tb-Bouma sequences; bases of beds are sharp; tops of beds are either sharp or gradational with the overlying shale; top surfaces of beds are rippled; groove molds trend 230° to 260°; very few crinoid columnals. Clayshale is medium gray (N5) to olive gray (5Y4/1), weathers light olive gray (5Y5/2) to olive gray (5Y4/1); shows weak textural lamination; parting is 3 mm thick; a few light brown (5YR5/6) spores (?) on bedding planes. Three highly fossiliferous limestone beds 0.15 to 0.4 ft thick below power line support structure in middle of unit; each bed weathers olive gray (5Y4/1), and consists of a grain supported aggregate of crinoid columnals near base of beds and brachiopod shell fragments near top of beds; the matrix material is silt and clay; shells are		

		Thickness (feet) Unit	Cum.
	subparallel with bedding in both concave-up and convex-up positions; rounded clay galls up to 1.5 cm in diameter are common; fossils include Atrypa spinosa Hall, Carnifella sp., and Spirifer sp. Culvert under highway near top of unit.....	105.0	2307.5
42.	Clayshale (80 percent) with beds of siltstone (20 percent) up to 0.3 ft thick, modal bed thickness is 0.15 ft. Clayshale is olive gray (5Y3/2), weathers light olive gray (5Y5/2); shows textural lamination; slightly silty; parting is 3 to 5 mm thick; light brown (5YR5/6) spores (?) on bedding planes. Siltstone is medium gray (N5), weathers olive gray (5Y3/2), and is finely micaceous.....	7.2	2202.5
41.	Siltstone (70 percent) in beds up to 1.0 ft thick, 20 percent of beds are greater than 0.2 ft thick, with interbeds of clayshale (30 percent). Siltstone is medium gray (N5), weathers olive gray (5Y4/1); top surfaces of beds are rippled; very few crinoid columnals, finely micaceous, sole markings in lower 10 ft trending 240° to 280°. Clayshale is light olive gray (5Y5/2), weathers olive gray (5Y4/1); shows textural lamination; locally slightly silty; parting is 1 to 3 mm thick. Culvert under highway near middle of unit.....	47.8	2195.3
40.	Mudstone, medium dark gray (N4), weathers olive gray (5Y5/2); hackly parting 5 mm thick; crinoid columnals and Ambocoelia (?) occur both as fossiliferous streaks and disseminated in mudstone; weathers to small irregular pieces and spheroidally in places. A few distinct siltstone beds. Some slight structural disturbances in this unit.....	78.4	2147.5
39.	Siltstone (50 to 60 percent) in beds up to 6.6 ft thick, approximately 60 percent of beds are greater than 0.3 ft thick, with interbeds of mudstone (40 to 50 percent)		

		Thickness (feet) Unit	Cum.
	generally less than 0.3 ft thick. Siltstone is medium gray (N5), weathers light olive gray (5Y5/2); evenly bedded; sole markings are common and show a mean trend of 262°; Ta- and Tb- Bouma sequences predominate; basal contacts of beds are sharp; top contacts are either sharp or gradational; a few hypichnial ridges and fossiliferous streaks. Upper 6.6 ft of unit is massive, argillaceous siltstone with no internal stratification; possibly several amalgamated beds; weathers to a rounded profile; top contact is abrupt; a few crinoid columnals and Ambocoelia sp. Mudstone is dark gray (N3) to olive gray (5Y4/1), weathers olive gray (5Y4/1) to medium dark gray (N4); irregular parting 3 to 5 mm thick; a few Ambocoelia (?); some zones distinctly bioturbated.....	67.8	2069.1
38.	Mudstone, olive gray (5Y4/1), weathers light olive gray (5Y5/2); hackly parting 7 to 10 mm thick; a few Ambocoelia sp., some are articulated. Curve warning sign at base of unit.....	8.8	2001.3
37.	Mudstone (85 to 90 percent) with beds of siltstone (10 to 15 percent) up to 0.35 ft thick, modal bed thickness is 0.15 ft. Mudstone is olive gray (5Y4/1), brownish black (5YR2/1) weathering stain is common; hackly parting 5 to 10 mm thick; very silty. Some structural disturbance in middle of unit.	9.0	1992.5
36.	Siltstone (60 to 70 percent) in beds up to 1.0 ft thick, beds greater than 0.25 ft thick are common, with interbeds of mudstone (30 to 40 percent). Ta- Bouma sequences predominate in siltstone beds; plane lamination or sinusoidal lamination is present in the upper parts of some beds; groove molds at base of unit trend 260°. Mudstone is olive gray (5Y4/1) to light olive gray (5Y5/2), weathers light olive gray		

		Thickness (feet) Unit	Cum.
	(5Y5/2) to brownish black (5YR2/1); hackly parting 5 to 10 mm thick; very silty.....	7.7	1983.5
35.	Mudstone (95 percent) with minor beds of siltstone (5 percent) less than 0.1 ft thick. Mudstone is olive gray (5Y4/1) to light olive gray (5Y6/1), weathers olive gray (5Y4/1) to light gray (N7); hackly parting 5 mm thick; becomes less silty upward; a few Ambocoelia sp.....	11.0	1975.8
34.	Siltstone (up to 70 percent, decreasing in abundance upwards) in beds up to 1.3 ft thick, modal bed thickness is 0.2 ft, with interbeds of mudshale or mudstone. Siltstone is medium gray (N5) to light olive gray (5Y5/2), weathers light olive gray (5Y5/2); evenly bedded; thinning upward in unit; groove mold at 11 ft above base of unit trends 260°; trace fossil Cylindrichnus in upper 10 ft of unit, 10 to 15 cm long, less than 1 cm wide and clay-filled. Mudstone is olive gray (5Y4/1); micaceous; hackly parting 3 to 5 mm thick. Mudshale in lower 3.5 ft of unit is medium dark gray (N4), weathers medium gray (N5); shows textural lamination; parting is less than 3 mm thick. Base of unit 34 is immediately below power line support structure.....	32.3	1964.8
33.	Mudstone, medium light gray (N6) to olive gray (5Y4/1); strongly bioturbated; bioturbated portions weather yellowish gray (5Y8/1); a few robust, costate brachiopods (Camarotoechia?).....	7.0	1932.5
32.	Mudstone (70 percent) with beds of siltstone (30 percent) 1 cm to 0.6 ft thick, modal bed thickness is 0.1 ft. Mudstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); micaceous; hackly parting 3 to 5 mm thick. Siltstone is light olive gray (5Y6/1), weathers olive gray (5Y4/1); micaceous; beds predominantly show Tb-		

		Thickness (feet) Unit	Cum.
	Bouma sequences; beds less than 0.15 ft thick have rippled top surfaces.....	9.9	1925.5
31.	Siltstone (80 percent) in beds up to 0.9 ft thick, modal bed thickness is 0.4 ft, with interbeds of mudstone (20 percent). Siltstone is medium gray (N5), weathers light olive gray (5Y5/2); micaceous; Tb- Bouma sequences; trace fossil Cylindrichnus near top of unit; a few crinoid columnals concentrated in layers. Mudstone is olive gray (5Y4/1), weathers dusky brown (5YR2/2); very silty; micaceous; hackly parting 5 to 10 mm thick. Resistant unit, forms vertical face.....	15.6	1915.6
30.	Mudstone as in unit 31 (80 percent) with beds of siltstone (20 percent) up to 0.9 ft thick, modal bed thickness is 0.15 ft. Siltstone is medium gray (N5), weathers light olive gray (5Y5/2); finely micaceous; groove mold in lower five ft of unit trends 260°.....	27.5	1900.0
29.	Covered. High voltage power lines cross over highway near middle of unit. Thickness estimated geometrically from map locations of outcrops, strike and dip data, and altitude data obtained with surveying altimeter accurate to ± 3 ft. Offset to exposures along east side of Virginia Highway 100, 100 ft north of where small creek passes under road.....	590+	1872.5
28.	Mudstone (85 percent) and mudshale (10 percent) with minor beds of siltstone (5 percent) up to 0.15 ft thick. Mudstone is olive gray (5Y4/1), very silty, hackly parting 3 to 5 mm thick. Mudshale is grayish black (N2); shows textural lamination; muds occur as three beds 3.6, 1.4, and 2.0 ft thick at 7.2, 20.1 and 26.2 ft above base of unit, respectively. Groove mold at 17.0 ft above base of unit trends 268°.....	40.8	1282.5

		Thickness (feet) Unit	Cum.
27.	Clayshale (85 percent) with beds of siltstone (15 percent) up to 0.5 ft thick. Clayshale is medium gray (N5) to grayish black (N2), weathers dark gray (N3); shows textural lamination; silt laminae and streaks up to 1 mm thick are common; parting is 2 mm thick; brittle. Unit 27 grades downward into unit 26 by increase in siltstone abundance and bed thickness; siltstone abundance increases from 10 percent at top of unit 27 to 30 percent at base of unit 27.....	42.4	1241.7
26.	Siltstone (60 percent) in beds up to 0.6 ft thick, modal bed thickness is 0.2 ft, with interbeds of mudshale (40 percent). Siltstone is medium gray (N5) to light olive gray (5Y5/2); weathers light olive gray (5Y5/2); micaceous; increases in abundance and bed thickness to a maximum in middle of unit where siltstone comprises 80 percent of section; abundant flute and groove molds trend 280° to 284°; a few distinct siltstone beds grade upward into less resistant argillaceous siltstone. Shale character is variable. Mudshale is predominantly olive gray (5Y4/1); weathers light olive gray (5Y5/2); shows textural lamination, irregular parting 3 to 5 mm thick; also present are intervals of dark gray (N3) to black (N1) mudshale and clayshale, 1 ft to 6 ft thick, which comprise 15 percent of the unit; this shale shows textural lamination, smooth parting 1 to 4 mm thick, grayish brown (5YR3/2) iron stain on parting surfaces. Upper 20 ft of unit 26 forms a vertical face on outcrop.....	131.7	1199.5
25.	Mudshale (80 percent) and clayshale (5 percent) with beds of siltstone (15 percent) 1 cm to 0.35 ft thick, modal bed thickness is 0.1 ft. Siltstone abundance increases from 10 percent at base of unit to 20 percent at top of unit. Mudshale is olive		

		Thickness (feet) Unit	Cum.
	gray (5Y3/2); shows textural lamination; parting is 4 mm thick. Clayshale is dark gray (N3), occurs in zones less than 1.4 ft thick, shows textural lamination, partings are 2 mm thick, grayish brown (5YR3/2) iron stain on parting surfaces; soft; forms recesses in outcrop. Sole markings are common; flute and groove molds trend 269° to 283°; convolute lamination in one siltstone bed 0.3 ft thick at 34 ft above base of unit.....	83.3	1067.8
24.	Covered. "Maximum Safe Speed 50" sign at base of unit 24.....	30.0	984.5
23.	Mudstone (95 percent) with minor beds of siltstone (5 percent) up to 0.2 ft thick, modal bed thickness is less than 0.1 ft. Mudstone is olive gray (5Y3/2); parting is 4 mm thick; weathers to small, brittle chips. Siltstone beds are laminated or cross-laminated.....	35.0	954.5
22.	Siltstone (50 percent) in beds 1 cm to 0.8 ft thick, with thin interbeds of mudstone (50 percent) less than 0.25 ft thick. Siltstone is olive gray (5Y3/2); bed thickness increases upward; irregular parting 1 cm thick is common in highly weathered siltstone beds. Mudstone is olive gray (5Y3/2), weathers light olive gray (5Y5/2), parting is 3 to 5 mm thick; minor dark gray (N3) shale showing textural lamination. Unit 22 forms protrusion of outcrop.....	20.7	919.5
21.	Clayshale (95 percent) with minor beds of siltstone (5 percent) less than 0.1 ft thick. Abundance of siltstone beds increases slightly upward in unit. Clayshale is dark gray (N3) to olive gray (5Y2/1), weathers olive gray (5Y4/1); shows textural lamination; slightly silty, becomes more silty upward in unit; parting is 2 to 4 mm thick. Siltstone beds are cross-laminated..	20.4	884.5

		Thickness (feet) Unit	Cum.
20.	Clayshale to mudshale (70 to 80 percent) with beds of siltstone (20 to 30 percent) up to 0.5 ft thick, modal bed thickness is 0.15 ft. Siltstone abundance increases to a maximum of 40 percent in upper half of unit, where bed thickness is also at a maximum; beds 1 to 2 cm thick are very common. Shale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; parting is 3 to 5 mm thick. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); a few beds with sole markings, mainly hypichnial ridges resembling Paleophycus; convolute lamination in 0.5 ft thick bed 22 ft below top of unit. "Help Prevent Forest Fires" sign across highway from middle of unit.....	32.0	864.1
19.	Mudshale to clayshale (80 to 85 percent) with beds of siltstone (15 to 20 percent) up to 0.25 ft thick, modal bed thickness is less than 0.1 ft. Shale is dark gray (N3) to grayish black (N2), weathers medium dark gray (N4) to dark gray (N5); shows textural lamination; silty at base of unit; parting is 1 to 4 mm thick; blackish red (5R2/2) iron stain on parting surfaces; weathers to smooth, even chips. Unit 19 is gradational with unit 20 in siltstone abundance and bed thickness.....	42.8	832.1
18.	Clayshale, (98 percent) with a few beds of siltstone (2 percent) less than 0.1 ft thick. Clayshale is olive gray (5Y3/2), weathers light olive gray (5Y5/2); shows textural lamination; a few silt laminae less than 2 mm thick; locally slightly silty; parting is 1 to 3 mm thick.....	52.2	789.3
17.	Covered; minor exposures of olive gray mudshale in ditch.....	55.0	737.1

		Thickness (feet) Unit	Cum.
16.	Mudstone (98 percent) with a few beds of siltstone (2 percent) up to 0.5 ft thick, predominantly less than 0.1 ft thick. Mudstone is olive gray (5Y3/2) to light olive gray (5Y5/2), weathers olive gray (5Y4/1); hackly parting, 3 to 5 mm thick; some distinct horizontal burrows 3 to 5 mm wide, weathering light brown (5YR5/6). Unit 16 is similar in appearance to unit 18.	212.0	682.1
15.	Covered.....	50.0	470.1

NOTE: Unit 14 is described in ditch approximately 30 ft off highway.

14.	Mudshale (60 percent) with beds of siltstone (40 percent) up to 1.1 ft thick, in a thickening- and coarsening-upward sequence; modal bed thickness is 0.1 ft. Siltstone abundance ranges from 30 percent in lower 5 ft of unit to 70 percent in upper 5 ft of unit. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; parting is 2 to 5 mm thick. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); sole markings; two beds 1.1 ft thick at top of unit, lower bed shows Tbc Bouma sequence, upper bed shows Tbcde Bouma sequence.....	20.0	420.1
13.	Covered. Offset to exposures on west side of highway along creek bank.....	14.6	400.1
12.	Siltstone and very-fine-grained sandstone (50 percent) in beds 0.1 ft to 1.3 ft thick, with thin interbeds of mudshale (50 percent). Siltstone and sandstone bed thickness and abundance increase towards middle of unit. Siltstone and sandstone are medium gray (N5) to light olive gray (5Y6/1); evenly bedded, except for very thin beds with undulatory, rippled top surfaces; minor amalgamation of beds; sole markings, mainly hypichnial ridges resembling Paleophycus and groove molds trending 318°; micaceous,		

		Thickness (feet) Unit	Cum.
	mica content increases upward in some beds; tiny black fragments of organic matter. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2) to light gray (N7); shows textural lamination; micaceous; parting is 2 to 5 mm thick.....	19.4	385.5

NOTE: Units 9 to 11 are described at exposures low on hill, west side of road. Top of unit 11 is directly above culvert where creek passes under highway.

11.	Mudshale (95 percent) with minor beds of siltstone (5 percent) predominantly less than 0.1 ft thick. Mudshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows weak textural lamination; very few silt laminae 1 to 2 mm thick; parting is 3 to 5 mm thick.....	29.1	366.1
10.	Covered.....	12.0	337.0
9.	Mudshale (85 percent) with beds of siltstone (15 percent) up to 0.4 ft thick, modal bed thickness is less than 0.1 ft. Mudshale is medium dark gray (N4), weathers light olive gray (5Y5/2); shows weak textural lamination; parting is 2 to 5 mm thick. Siltstone is medium gray (N5); beds are predominantly cross-laminated; upper surfaces of beds are rippled; groove mold at 4 ft above base of unit trends 235°.....	18.4	325.0
8.	Covered. Offset to exposure at top of shale pit behind French's Chapel.....	121.6	306.6
7.	Clayshale, dark gray (N3), weathers medium dark gray (N4); shows strong textural lamination; color lamination less than 0.5 mm thick; silt-free; smooth parting 2 to 5 mm thick.....	28.5	185.0
6.	Claystone, olive gray (5Y4/1) to yellowish gray (5Y8/1), weathers light olive gray (5Y5/2) to yellowish gray (5Y8/1); weakly to completely bioturbated; burrows are		

		Thickness (feet) Unit	Cum.
	indistinct, horizontal, 1 to 2 mm wide and weather yellowish gray (5Y8/1); biolamination and streaks are common; bioturbation increases toward silty zone in middle of unit. In upper 2.0 ft of unit there are several 0.1 to 0.3 ft thick siltstone beds; in the interval 1 to 3 ft below top of unit there are several thin interbeds of grayish black (N2) clayshale showing fine textural lamination; upper 1.0 ft of unit is claystone, light brownish gray (5YR6/1), weathers brownish gray (5YR4/1); many tiny dark flecks of organic material...	22.2	156.5
5.	Clayshale, olive gray (5Y4/1), weathers light olive gray (5Y5/2); silt-free; shows textural lamination and few silt laminae less than 1 mm thick. Several cross-laminated and plane laminated siltstone beds less than 0.1 ft thick; at top of unit there is a 0.6 ft thick bed of very-fine-grained sandstone.....	46.0	134.3
4.	Claystone, olive gray (5Y4/1) to medium light gray (N6), weathers light olive gray (5Y5/2); silt-free; moderately bioturbated; burrows are indistinct, horizontal, and less than 5 mm wide; bioturbated portions weather yellowish gray (5Y8/1); biolaminae up to 3 mm thick are common; tiny pelecypods 2 to 5 mm wide.....	3.2	88.3
3.	Claystone and clayshale, medium dark gray (N4) to olive gray (5Y4/1), weather light olive gray (5Y5/2); micaceous; slightly silty; weak textural lamination in clay-shale; minor burrow mottling as in unit 4; parting is 2 to 5 mm thick. A few siltstone beds 1 to 2 cm thick, either laminated or cross-laminated; a 2 cm thick bed at 5.6 ft below top of unit has groove mold and parting lineation trending 271° and 285°, respectively.....	35.4	85.1

	Thickness (feet) Unit	Cum.
2. Sandstone, very-fine-grained, single bed, light olive gray (5Y5/2); micaceous; mica content increases upward; shows Tab Bouma sequence; crinoid columnals are abundant in basal 0.1 ft and diminish in abundance upward.....	1.3	49.7
Total Brallier Formation.....	3580.8	
Millboro Shale (incomplete):		
1. Mudshale, dark gray (N3) to olive black (5Y2/1), weathers medium dark gray (N4); shows weak textural lamination; finely micaceous; parting is 5 to 10 mm thick. A few indistinct siltstone beds 1 to 2 cm thick in lower 10 ft of unit; non-resistant; plane laminated or cross-laminated; weather dark yellowish orange (10YR6/6). A few sideritic layers less than 0.1 ft thick are also present in lower 10 ft of unit and weather dark yellowish orange (5YR6/6). Several beds of less resistant shale up to 0.4 ft thick; these beds weather medium gray (N5), and show incipient spheroidal weathering and parting 1 to 2 cm thick.....	48.4	48.4
Total Millboro Shale (incomplete).....	48.4	

SECTION 19

White Gate Section

Section of siltstone bundle in Brallier Formation, exposed in roadcut along Virginia Route 601, 0.5 mile north of Sassin Church, Pulaski County, White Gate quadrangle, Virginia (519000 meters east, 4112900 meters north, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, August 27, 1978.

Devonian (incomplete):	Thickness (feet)	
Brallier Formation (incomplete):	Unit	Cum.
3. Clayshale (95 percent) with beds of siltstone (5 percent) less than 0.1 ft thick. Clayshale is olive gray (5Y3/2) weathers light olive gray (5Y5/2); shows textural lamination; parting is 2 to 4 mm thick. Siltstone beds are cross-laminated.....	6.1	50.9
2. Siltstone (66 percent) in beds less than 0.1 ft to 3.4 ft thick, modal bed thickness is 0.2 ft, 50 percent of beds are greater than 0.35 ft thick; interbeds are clayshale as in unit 3 (44 percent). Unit 2 was measured and described in bed by bed detail. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); evenly bedded; base of beds are flat and sharply defined; 57 percent of beds show Ta- Bouma sequences, 30 percent show Tb- Bouma sequences, 11 percent show Tc- Bouma sequences; unit ABC proximity index (Walker, 1967) is 75 percent.....	35.6	44.2
1. Clayshale as in unit 3 (90 percent) with 8 beds of siltstone (10 percent) up to 0.2 ft thick; 5 beds show Tb- Bouma sequences; 3 beds are structureless and less than 0.1 ft thick.....	9.2	9.2
Total Brallier Formation (incomplete)..	50.9	

SECTION 20

Gauley Ridge Section

Incomplete section of lower Brallier Formation exposed in roadcuts on both sides of Virginia Route 606 at prominent northeast trending ridge, called Gauley Ridge, 1.2 miles east of Holly Brook, Bland County, Mechanicsburg quadrangle, Virginia (502560 meters east, 4115620 meters north, Universal Transverse Mercator grid). Gauley Ridge is formed by a siltstone bundle (Unit 2). Section measured, described and sampled at exposures on north side of road using Jacob's staff, Abney level, and tape by Paul D. Lundegard, September 22, 1977.

Devonian (incomplete):	Thickness (feet)	
Brallier Formation (incomplete):	Unit	Cum.
5. Mudshale, with a few beds of siltstone (less than 1 percent) less than 0.1 ft thick. Mudshale is light olive gray (5Y5/2), and weathers light olive gray (5Y5/2); shows weak textural lamination; micaceous; parting is 3 to 5 mm thick; numerous indistinct horizontal burrows give some bedding planes a rough, irregular surface; burrows are less than 5 mm wide; weathers to small platy or tabular chips. Siltstone beds are cross-laminated.....	50.0	150.0
4. Covered.....	13.0	100.0
3. Clayshale with a few beds of siltstone (less than 2 percent) less than 2 cm thick. Clayshale is light olive gray (5Y5/2), and weathers light olive gray (5Y5/2); shows textural lamination; locally silty; parting is 5 mm thick. Siltstone beds are plane laminated or cross-laminated.....	9.8	87.0
2. Siltstone and very-fine-grained sandstone (85 percent) in beds up to 2.3 ft thick, modal bed thicknesses of 0.2 ft and 1.5 ft with interbeds of clayshale (15 percent). Unit 2 was described in bed by bed detail. Siltstone and sandstone are medium gray (N5); micaceous; rounded, flat, clay galls up to 4 cm long are common; tiny, unoriented wood fragments are abundant near the tops of several beds; on outcrop scale beds are strikingly parallel and even; ripple marks form small scale irregularities on top surfaces of many beds; sole markings are rare; 60 percent of beds show Ta- Bouma sequences, 20 percent show Tb- Bouma sequences, and 13 percent show Tc- Bouma sequences; over 40 percent of beds are cross-laminated in their upper parts; the unit ABC proximity index (Walker, 1967) is 70 percent. Clayshale interbeds are generally less than 0.2 ft thick; medium dark gray (N4), weather medium dark gray (N4) to medium gray (N5); show textural lamination; parting is 1 to 5 mm thick.....	25.6	77.2

	Thickness (feet) Unit	Cum.
1. Clayshale and mudshale (98 percent) with a few beds of siltstone (2 percent) less than 0.25 ft thick. Lower third of unit is light olive gray (5Y5/2) clayshale, with minor beds of medium gray (N5) mudshale; upper two-thirds of unit is predominantly medium gray mudshale; textural lamination is best developed in medium gray shale; parting is 3 to 5 mm thick in light olive gray shale and 2 to 4 mm thick in medium gray shale; some horizontal burrows less than 5 mm wide. At 18.5 ft above base of unit there is a 0.4 ft thick bed of light gray (N7) claystone with abundant medium gray (N5) burrow mottles; this bed is silt-free and weathers to a recess. Siltstone beds are cross-laminated, or ripple drift cross-laminated; several beds grade into surrounding shales; ripple crests at 27.0 ft above base of unit trend 155° with current towards the southwest.....	51.6	51.6
Brallier Formation (incomplete).....	150.0	

SECTION 21

South Gap Section

Section of siltstone bundle in basal Brallier Formation, exposed at top of South Gap-Virginia Route 606 exit ramp along Interstate Highway 77-north, Bland County, Rocky Gap quadrangle, Virginia (491800 meters east, 4118350 meters north, Universal Transverse Mercator grid). Section measured and described using tape by Paul D. Lundegard, July 19, 1978.

Devonian (incomplete):

Brallier Formation (incomplete):		
3. Clayshale, olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; parting is 2 to 3 mm thick.....	20.0	57.0

		Thickness (feet) Unit	Cum.
2.	Siltstone (60 percent) in beds 1 cm to 2.5 ft thick, modal bed thickness is less than 0.2 ft, 30 percent of beds are greater than 0.4 ft thick; interbeds are clayshale as in unit 3 (40 percent). Unit 2 was measured and described in bed by bed detail. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); beds show sharp basal contacts and sharp or slightly gradational upper contacts; 46 percent of beds show Ta- Bouma sequences, 30 percent show Tb- Bouma sequences, 12 percent show Tc- Bouma sequences, and 12 percent show plane lamination interpreted to represent the Bouma Td division; the unit ABC proximity index (Walker, 1967) is 61 percent; clay galls occur in 2 beds; 1.9 ft thick bed at 8.8 ft above base of unit grades from very-fine-grained sandstone at its base to siltstone at its top...	22.0	37.0
1.	Clayshale as in unit 3.....	15.0	15.0
	Total Brallier Formation (incomplete)..	57.0	

SECTION 22

Bastian Section

One of the best and most nearly complete sections of the Brallier Formation in southwest Virginia, exposed mainly in roadcuts along U.S. Highway 21-52 from the town of Bastian, southward to 0.4 mile south of the crest of Brushy Mountain in Bland County, Bastian quadrangle.

Base of section is 200 feet south of junction of U.S. Highway 21-52 and Virginia Route 615 on east side of U.S. Highway 21-52 in the town of Bastian (486700 meters East, 4111500 meters North, Universal Transverse Mercator grid). Uppermost Brallier Formation and "Chemung" Formation, units 41 through 62, are described at roadcuts from the crest of Brushy Mountain south for approximately 0.4 mile. Section was measured and described using Jacob's staff, Abney level, surveying altimeter and tape by Paul Lundegard, August 30 and 31, and September 1, and 2, 1978.

Devonian (incomplete):	Thickness (feet)	
"Chemung" Formation (incomplete):	Unit	Cum.
62. Sandstone, very-fine-grained (75 percent, decreasing upward to 30 percent in upper 15 ft) in beds up to 1.2 ft thick, predominantly 0.2 to 0.6 ft thick, with interbeds of mudshale (25 to 60 percent). Sandstone is olive gray (5Y4/1) to light olive gray (5Y5/2) with tiny limonite specks on fresh surfaces; beds are uneven to discontinuous; low-angle crossbedding and plane lamination common; fossiliferous, especially at 2 ft above base; fossils include crinoid columnals, Camarotoechia sp., Spirifer sp. brachiopods, and Lyriopecten sp., and Nucula (?) pelecypods. Mudshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); shows textural lamination, parting is 3 to 5 mm thick; beds folded and culvert under road at base of unit.....	45.0	3384.5
61. Mudstone, dark yellowish brown (10YR4/2), weathers light olive gray (5Y5/2); very silty; hackly parting; strongly bioturbated; a few distinct horizontal burrows less than 7 mm wide; a few imprints of brachiopods. Beds steeply inclined. Unit 61 forms slight recess in outcrop.....	6.2	3339.5
60. Siltstone, coarse-grained, and sandstone, very-fine-grained (80 percent) in beds up to 0.8 ft thick, predominantly 0.2 to 0.6 ft thick, with interbeds of mudshale as in unit 62 (20 percent). Siltstone and sandstone beds are uneven to discontinuous; beds show predominantly plane or undulatory lamination with some crossbedding; flaggy parting; very fossiliferous; fossils include Camarotoechia sp. brachiopods, Leptodesma sp. pelecypods, and crinoid columnals; highly fossiliferous lens 0.8 ft thick at 3.0 ft below top of unit. Dip of beds increases abruptly at top of unit...	14.4	3333.3
59. Mudshale to mudstone (60 percent) with beds of coarse-grained siltstone (30 percent) up to 0.3 ft thick, modal bed thickness is		

		Thickness (feet) Unit	Cum.
	0.1 ft. Mudshale and mudstone are olive gray (5Y4/1), weather light olive gray (5Y5/2); mudshale shows textural lamination. Siltstone is light olive gray (5Y5/2); beds are uneven; fossiliferous; fossils include Camarotoechia sp. Unit 59 is gradational with unit 60; bed thickness increases slightly at top of unit 59.....	14.4	3318.9
58.	Sandstone, very-fine-grained, olive gray (5Y4/1) with limonite specks on fresh surface, weathers light olive gray (5Y5/2); beds are 0.3 ft to 1.4 ft thick; cross-bedded; clay galls; highly fossiliferous; contains Camarotoechia sp. and other brachiopods; some bioturbation.....	3.0	3304.5
57.	Mudstone, olive gray (5Y4/1), weathers light olive gray (5Y5/2).....	2.0	3301.5
56.	Deformed zone; beds tightly folded and faulted; poorly exposed; stratigraphic thickness uncertain.....	40.0	3299.5
55.	Sandstone, very-fine-grained, and siltstone, coarse-grained (50 percent), in beds 0.3 to 0.1 ft thick with interbeds of mudstone (50 percent). Sandstone and siltstone are light olive gray (5Y5/2) to moderate olive brown (5Y4/4); beds are concentrated in 3 groups; show plane lamination, undulatory lamination and crossbedding; a few fossils in middle of unit. Mudstone is light olive gray (5Y5/2); very silty; hackly parting; bioturbated; contains Camarotoechia sp. brachiopods, and Nucula sp., and Leptodesma (?) pelecypods. Dip of beds increases at top of unit.....	36.0	3259.5
54.	Poorly exposed; sandstone, very-fine-grained, light olive gray (5Y5/2); platy; one bed 1.2 ft thick, shows low-angle crossbedding in 0.8 ft sets.....	13.0	3223.5

		Thickness (feet) Unit	Cum.
53.	Covered; culvert under road marked by white post in middle of unit.....	9.0	3210.5
52.	Siltstone, coarse-grained, and sandstone, very-fine-grained (75 percent), in beds 0.3 ft to 1.5 ft thick, modal bed thickness is 0.7 ft, with interbeds of mudstone (25 percent). Siltstone and sandstone beds are plane laminated or crossbedded; some indistinct horizontal bioturbation; 2 flaggy beds in middle of unit 1.0 to 1.5 ft thick. Mudstone is light olive gray (5Y5/2); very silty; strongly bioturbated; hackly parting.....	16.8	3201.5
51.	Mudstone as in unit 52 (90 to 95 percent) with beds of coarse-grained siltstone (5 to 10 percent) 0.1 to 0.4 ft thick. Several siltstone beds appear to pinch out into mudstone.....	15.6	3184.7
50.	Sandstone, very-fine-grained, and siltstone, coarse-grained (85 percent), in beds 0.2 ft to 1.5 ft thick with interbeds of mudstone as in unit 52 (15 percent) predominantly less than 0.15 ft thick. Sandstone and siltstone are light olive gray (5Y5/2); beds are predominantly plane laminated; some low-angle crossbedding; many beds strongly bioturbated; low-angle clay-filled burrows up to 1 cm wide; faint remnant lamination or cross-lamination in some bioturbated zones.....	38.8	3169.1
	Total "Chemung" Formation (incomplete).	254.2	

Brallier Formation:

49.	Mudstone (75 percent) with beds of siltstone (25 percent) up to 0.5 ft thick, modal bed thickness is 0.3 ft. Mudstone is light olive gray (5Y5/2); strongly bioturbated, burrows are predominantly low-angle and less than 7 mm wide; hackly parting. Siltstone occurs		

		Thickness (feet) Unit	Cum.
	as even, well defined beds and also as strongly bioturbated argillaceous siltstone with very indistinct bedding; burrows are horizontal to inclined, up to 1 cm wide, and have clayey fillings; branching of burrows is rare; a few similar burrows are present in the distinct siltstone beds; small talus cone is present below 4 ft thick interval of bioturbated argillaceous siltstone at 17 ft above base of unit; crossbedded distinct siltstone, 0.5 ft thick at 10 ft below top of unit.....	64.3	3130.3
48.	Mudstone as in unit 49 (95 percent) with minor beds of siltstone (5 percent) up to 0.6 ft thick, modal bed thickness is less than 0.1 ft. Six feet of section is covered where culvert, marked by white post, passes under road near middle of unit.	59.5	3066.0
47.	Covered. "Winding Road" sign facing north near middle of unit.....	47.0	3066.5
46.	Mudstone (50 to 60 percent) with beds of siltstone (40 to 50 percent) up to 0.8 ft thick, modal bed thickness is 0.4 ft. Mudstone is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); some distinct horizontal burrows. Ta- Bouma sequences are very common in siltstone beds; sole markings are common; flute molds near middle of unit trend 258°. Gentle fold near top of unit.....	62.1	2959.5
45.	Clayshale (85 percent) with beds of siltstone (15 percent) up to 0.5 ft thick, modal bed thickness is 0.15 ft. Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); shows textural lamination; silt-free; parting is 5 mm thick. Tbcde and Tcde Bouma sequences predominate in siltstone beds; sole markings are common; flute molds near middle of unit trend 284°.....	4.1	2897.4

		Thickness (feet) Unit	Cum.
44.	Clayshale as in unit 45 (70 percent) with beds of siltstone (30 percent) up to 0.8 ft thick, modal bed thickness is 0.25 ft; 7 siltstone beds 0.5 ft thick or greater are distinctive of unit 44. Siltstone is light olive gray (5Y5/2); Tb- and Tab- Bouma sequences predominate.....	18.2	2893.3
43.	Clayshale as in unit 45 (90 percent) with beds of siltstone (10 percent) up to 0.7 ft thick, predominantly less than 0.2 ft thick. In siltstone beds Tc- and Tbc- Bouma sequences predominate; top surface of beds are commonly rippled. Minor claystone where textural lamination is absent in fine-grained interbeds. "Deer Trail Park Campground" sign on hill above outcrop.....	15.6	2875.1
42.	Covered. "Goins" home across road from base of unit.....	12.0	2859.5
41.	Claystone (65 percent) with beds of siltstone (35 percent) up to 0.5 ft thick, modal bed thickness is 0.15 ft. Claystone is light olive gray (5Y5/2); slightly silty; numerous distinct horizontal burrows. Siltstone beds are even, and commonly have rippled top surfaces; Tabc and Tc Bouma sequences are common; low relief sole markings; groove molds 2 ft above base of unit trend 252°. Middle 5 ft of unit is more thinly bedded; beds in this interval are less than 0.15 ft thick and cross-laminated. Unit 41 is described at roadcut next to "Maximum Safe Speed 30" sign, 0.05 mile south of crest of Brushy Mountain.....	23.0	2847.5
40.	Siltstone (80 percent) in beds up to 1.0 ft thick, modal bed thickness is 0.2 ft, with interbeds of clayshale or mudshale (20 percent) less than 0.15 ft thick. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); beds have sharp bases and		

		Thickness (feet) Unit	Cum.
	sharp or gradational tops; Ta-, Tb-, and Tc- Bouma sequences occur throughout unit; Tc- sequences are most common overall; abundant sole markings include flute, groove, bounce, and prod molds, and hypichnial ridges; current formed sole marking orientations measured throughout unit have a strong average trend of 250°; carbonized plant fragments and clay galls are locally very common; convolute lamination and imprints of brachiopod shells occur in a few siltstone beds. Vertical and high-angle burrows are common in siltstone beds in upper 10 ft of unit; these include Cylindrichnus, Teichichnus, and simple burrows about 5 mm wide which are clay filled, straight to slightly curved, and rarely branched; horizontal burrows on the top surface of siltstone beds are common throughout unit. Shale is medium dark gray (N4), weathers medium gray (N5) to light olive gray (5Y5/2); shows textural lamination; locally silty; silt laminae are locally common. Upper 117 ft of unit 40 is described at high, steep exposures above Virginia Route 612, 300 feet from its junction with U.S. Highway 21-52; lower 53 ft of unit 40 is described at exposures along U.S. Highway 21-52, 400 ft downhill from the same junction. Top of unit 40 was correlated with base of unit 41 by tracing individual beds to the crest of Brushy Mountain, and measuring from there to base of unit 41 with Jacob's staff and Abney level. Upper 117 feet of unit 40 were measured and described in bed by bed detail.....	170.0	2824.5
39.	Covered; thickness uncertain due to structural disturbance at base of unit 40...	10.0	2654.5

NOTE: Unit 38 is described at high roadcut on west side of U.S. Highway 21-52, 0.25 mile north of Virginia Route 612.

	Thickness (feet) Unit	Cum.
38. Siltstone (75 percent) in beds up to 0.9 ft thick, modal bed thickness is 0.3 ft with interbeds of clayshale (25 percent). Siltstone is medium gray (N5); in lower 70 ft, Tc- and Tb- Bouma sequences predominate; from 70 ft above base to 25 ft below top of unit, Ta- Bouma sequences are most common; upper 25 ft of unit is thinner bedded than remainder of unit and Tc- and Tbc- Bouma sequences predominate. In general, beds less than or equal to 0.1 ft thick show Tc- Bouma sequences. Abundant current formed sole markings with a mean trend of 252°; a few beds contain clay galls; inclined, clay-filled burrows near tops of a few beds. Clayshale is medium dark gray (N4), weathers medium gray (N5); shows textural lamination; parting thickness is 2 mm or less.....	106.5	2644.5

NOTE: Units 37 through 32 are described at low outcrop on east side of U.S. Highway 21-52, 0.3 mile north of Virginia Route 612.

37. Clayshale (75 to 80 percent) with beds of siltstone (20 to 25 percent) up to 1.1 ft thick, modal bed thickness is 0.2 ft. Siltstone beds 0.2 to 0.3 ft thick are distinctive of unit 37. Clayshale is grayish black (N2), weathers medium dark gray (N4); shows very fine textural lamination; very slightly silty; parting is less than 3 mm thick with grayish red (5R4/2) iron stain on parting surfaces. Five ft thick interval at 20 ft above base of unit includes many siltstone beds less than 1.5 cm thick; these beds are mostly plane laminated or cross-laminated...	42.5	2538.0
36. Clayshale as in unit 37 (90 to 95 percent) with beds of siltstone (5 to 10 percent) up to 0.1 ft thick, modal bed thickness is 2 to 3 cm. Siltstone beds are even and persistent; Ta- Bouma sequences predominate.	9.0	2495.5

		Thickness (feet) Unit	Cum.
35.	Clayshale as in unit 37 (80 percent) with beds of siltstone (20 percent) up to 0.5 ft thick, modal bed thickness is 0.2 ft. Ta- and Tb- Bouma sequences predominate in siltstone beds.....	12.0	2486.5
34.	Clayshale as in unit 37 (greater than 95 percent) with beds of siltstone (less than 5 percent) up to 0.5 ft thick. At 4.0 feet above base of unit there are 2, 0.5 ft thick, structureless (Ta) siltstone beds.....	9.0	2474.5
33.	Clayshale as in unit 37 (70 percent) with beds of siltstone (30 percent) up to 1.0 ft thick, modal bed thickness is 0.2 ft. Approximately 60 percent of siltstone beds show Ta- Bouma sequences, the remainder show Tbc- and Tc- Bouma sequences; a 1.0 ft thick siltstone bed at 6.5 ft below top of unit.....	12.5	2465.5
32.	Clayshale as in unit 37 (95 percent) with beds of siltstone (5 percent) up to 0.5 ft thick, modal bed thickness is 0.1 ft. Tc- and Tbc- Bouma sequences predominate in siltstone beds; at 3.0 ft below top of unit there is a 0.5 ft thick structureless (Ta) siltstone bed.....	16.5	2453.0

NOTE: Between outcrops where units 31 and 32 were measured there is a steep, vetch-covered gully with a cement gutter at its base. Units 31 through 26 are described at roadcut on west side of U.S. Highway 21-52.

31. Clayshale (50 percent) and claystone (25 percent) with beds of siltstone (25 percent) up to 1.2 ft thick, modal bed thickness is 0.3 foot; siltstone beds 0.2 to 0.4 ft thick are distinctive of unit 31. Clayshale is grayish black (N2), weathers medium dark gray (N4); shows textural lamination; parting is 1 to 3 mm thick. Claystone is medium dark gray (N4), weathers medium gray (N5)

		Thickness (feet) Unit	Cum.
	to medium light gray (N6); contains a few carbonized wood fragments. Upper 6 ft of unit is 40 percent siltstone in 4 structureless (Ta) beds 0.3 ft to 1.2 ft thick.....	22.0	2436.5
30.	Siltstone (60 percent) in beds up to 0.9 ft thick, modal bed thickness is 0.3 ft, with interbeds of clayshale as in unit 31 (30 percent). Siltstone beds predominantly show Ta- Bouma sequences. Unit 30 is thicker bedded than units 31 and 29; an abrupt increase in the abundance of siltstone, and in siltstone bed thickness occurs at base of unit 30.....	13.0	2414.5
29.	Clayshale and minor claystone, both as in unit 31 (80 percent) with beds of siltstone (20 percent) up to 1.2 ft thick, modal bed thickness is 0.15 to 0.2 ft.....	17.0	2401.5
28.	Clayshale as in unit 31 (80 percent) with beds of siltstone (20 percent) up to 0.3 ft thick, modal bed thickness is less than 0.1 ft. Siltstone beds greater than 0.15 ft thick (15 percent) show Ta- Bouma sequences; beds less than 0.1 ft thick (85 percent) show Tc- or Tbc- Bouma sequences; plane laminated siltstone layers less than 1.5 cm thick are very common, these may represent Td rather than Tb Bouma units.....	16.0	2384.5
27.	Clayshale as in unit 31 and siltstone beds in a thickening-upward sequence. The abundance of siltstone increases from 10 percent near base of unit to 50 percent at top of unit. Bed thickness also increases upward; maximum bed thickness increases from 0.4 ft near base to 1.0 ft near top of unit; modal bed thickness increases from less than 0.1 ft near base to 0.2 ft near top of unit. Beds greater than 0.3 ft thick predominantly show Ta- Bouma sequences; beds less than 0.15 ft thick show Tc- and Tbc- Bouma sequences.		

		Thickness (feet) Unit	Cum.
	Groove molds at 7.3 ft below top of unit trend 263°; possible Zoophycus burrow at 13.5 ft above base of unit. High-angle normal fault with 5 ft of displacement cuts unit 27.....	31.0	2368.5
26.	Clayshale (80 percent) with beds of siltstone (20 percent) up to 1.4 ft thick, predominantly less than 0.4 ft thick, modal bed thickness is 0.15 ft. Clayshale is grayish black (N2), weathers medium dark gray (N4); shows textural lamination and a few discontinuous pinch and swell silt streaks less than 2 mm thick; parting is less than 3 mm thick; soft. Siltstone beds typically have rippled upper surfaces; overall, Tc- Bouma sequences are most common; Tbc- and Ta- Bouma sequences predominate in beds greater than 0.2 ft thick (5 percent); flute mold, 1.6 ft below top of unit trends 276°. Base of unit is above uphill end of a 300 ft long section of guardrail on west side of U.S. Highway 21-52.....	45.0	2337.5
25.	Covered; steep gully below U.S. Highway 21-52 on west side; 300 ft long section of guardrail on west side of highway; "Truckers Maximum Safe Speed 25" sign in middle of unit on east side of highway.....	112.5	2292.5

NOTE: Units 17 through 24 are described at outcrop on west side of U.S. Highway 21-52, just uphill of 0.3 mile long section of guardrail, and 0.9 mile south of Bastian.

24.	Clayshale (greater than 95 percent) with minor beds of siltstone (less than 5 percent) less than 0.1 ft thick. Clayshale is grayish black (N2), weathers medium dark gray (N4); fine textural lamination and a few silt laminae less than 0.5 mm thick; parting is 3 mm thick with grayish red (5R4/2) iron stain on parting surfaces.....	14.8	2180.0
23.	Clayshale as in unit 24 (85 percent) with beds of siltstone (15 percent) up to 0.7 ft thick. Siltstone beds predeominatly show Tb- or Tc- Bouma sequences; 3 beds 0.4 to 0.7 ft thick show Ta- Bouma sequences.....	11.2	2165.2

		Thickness (feet) Unit	Cum.
22.	Clayshale as in unit 24 (greater than 95 percent) with minor beds of siltstone (less than 5 percent) up to 0.1 ft thick, modal thickness is 1 to 2 cm. Approximately 80 percent of siltstone beds are plane laminated, remainder are cross-laminated....	12.0	2154.0
21.	Clayshale as in unit 24 (85 to 90 percent) with beds of siltstone (10 to 15 percent) up to 0.6 ft thick, predominantly less than 0.25 ft thick. Several siltstone beds 0.3 to 0.6 ft thick in upper 5 ft of unit. Siltstone beds less than 0.25 ft thick predominantly show Tb- Bouma sequences; Ta- Bouma sequences predominate in thicker beds.....	22.0	2142.0
20.	Clayshale as in unit 24 (65 percent) with beds of siltstone (35 percent) up to 0.7 ft thick. Variable bed thickness and siltstone beds 0.5 ft thick or greater are distinctive of unit 20. Unit 20 is gradational with overlying, thinner bedded, unit 21. Siltstone beds greater than 0.2 ft thick predominantly show Ta- Bouma sequences; beds 0.1 ft thick and less are predominantly structureless or plane laminated. Small prod molds and hypichnial ridges are common.....	16.2	2120.0
19.	Clayshale as in unit 24 (greater than 90 percent) with beds of siltstone (less than 10 percent) up to 0.4 ft thick, predominantly 0.1 ft thick or less. Siltstone beds are predominantly structureless; silt laminae 5 mm to 10 mm thick are common; these laminae are even and structureless.....	15.3	2103.8
18.	Clayshale as in unit 24 (70 to 80 percent) with beds of siltstone (20 to 30 percent) 0.1 to 1.3 ft thick in a thinning-upward sequence. Siltstone abundance decreases upward; modal bed thickness decreases upward from 0.5 to 0.1 ft; Ta- and Tb- Bouma sequences predominate near base of		

		Thickness (feet) Unit	Cum.
	unit; Tb-, Tbc-, and Tc- Bouma sequences predominate near top of unit. Siltstone beds have sharp basal contacts and sharp or gradational upper contacts; sole markings are common.....	26.0	2088.5
17.	Clayshale as in unit 24 (greater than 95 percent) with minor beds of siltstone (less than 5 percent) up to 0.15 ft thick. Base of unit 17 is above uphill end of a 0.3 mile long section of guardrail along west side of U.S. Highway 21-52, and across highway from "Truck Escape Ramp" sign.....	12.5	2062.5
16.	Covered. Section of guardrail 0.3 mile long along west side of U.S. Highway 21-52 in this interval. Thickness estimated geometrically from map locations of outcrops, strike and dip data, and altitude data obtained with a surveying altimeter accurate to ± 3 feet.....	835+	2050.0

NOTE: Units 7 through 15 are described at roadcut on west side of U.S. Highway 21-52, 0.5 mile south of Virginia Route 613 and town of Bastian.

15.	Mudstone (90 percent) with beds of siltstone (10 percent) up to 0.4 ft thick, predominantly 0.1 to 0.2 ft thick. Mudstone is olive gray (5Y4/1); very silty; horizontal and vertical burrows less than 7 mm wide are very common; some tiny carbonized wood fragments. In the 5 foot interval above the top of unit 15 there are several siltstone beds 0.3 ft to 1.3 ft thick; remainder of outcrop is inaccessible.....	18.0	1215.0
14.	Siltstone (70 percent), modal bed thickness is 0.7 ft, with interbeds of clayshale (30 percent), in a thinning-upward sequence. Siltstone is evenly bedded; beds have sharp bases and sharp or gradational tops, and are predominantly structureless; several siltstone beds		

		Thickness (feet) Unit	Cum.
	weather a distinctive light brown (5YR5/6). Clayshale is dark gray (N3), weathers medium dark gray (N4); very fine textural lamination; parting is 1 to 3 mm thick; soft. At road level unit 14 is directly across highway from "Truckers Maximum Safe Speed 15" sign.....	12.5	1197.0
13.	Mudstone (85 percent) with beds of siltstone (15 percent) up to 0.3 ft thick, modal bed thickness is 0.1 ft. Mudstone is dark gray (N3), weathers medium dark gray (N4); locally shows 2 to 3 mm thick parting; very few silt laminae less than 1 mm thick; a few horizontal and vertical burrows up to 7 mm wide.....	14.3	1184.5
12.	Mudstone as in unit 13 (60 to 70 percent) with beds of siltstone (30 to 40 percent) 0.2 to 1.0 ft thick; slight thinning-upward. Siltstone beds 0.5 to 1.0 ft thick are distinctive of unit 12; these beds are plane laminated (Tb) or structureless (Ta). At 8.4 ft above base of unit there is a 0.5 ft thick siltstone bed with many 1 to 3 cm long siderite nodules.....	10.0	1170.2
11.	Mudstone and minor claystone as in unit 13 (80 to 85 percent) with beds of siltstone (15 to 20 percent) up to 0.7 ft thick, but predominantly 0.1 to 0.4 ft thick, modal bed thickness is 0.2 ft. Siltstone abundance increases to 30 percent at top of unit. Claystone differs from mudstone only in silt content. Siltstone beds are even and persistent; many have sharp bases and gradational tops.....	91.6	1160.2
10.	Mudstone, claystone (10 to 60 percent) and siltstone (30 to 90 percent) in a thickening- and coarsening-upward sequence. Mudstone is as in unit 13. Claystone differs from mudstone only in disseminated silt content. Siltstone abundance ranges from		

		Thickness (feet) Unit	Cum.
	30 percent in lower 10 ft of unit to 90 percent in upper 7 ft. Siltstone bed thickness ranges from 0.1 to 0.4 ft in lower 10 ft of unit; and ranges from 0.5 ft to 1.5 ft in upper 7 ft of unit; beds are structureless in upper 7 ft; sole markings are common throughout unit; groove molds 6.8 ft above base of unit trend 234°.....	24.2	1068.6
9.	Claystone (80 to 85 percent) with beds of siltstone (15 to 20 percent) up to 0.4 ft thick, modal bed thickness is 0.2 ft; unit 9 is gradational with unit 8 below; siltstone content is 25 to 30 percent in lower 8 ft of unit. Claystone is dark gray (N3), weathers medium dark gray (N4); very few silt laminae less than 5 mm thick; parting is 1 to 2 mm thick; a few distinct horizontal and short vertical burrows up to 3 mm wide. Siltstone beds commonly show small, low-relief sole markings, mainly groove molds and prod molds.....	14.3	1044.3
8.	Claystone as in unit 9 (60 percent) with beds of siltstone (40 percent) up to 1.6 ft thick, modal bed thickness is 0.5 ft. Siltstone beds are predominantly structureless (Ta); sole markings are common; 1.6 ft thick siltstone bed at 2 ft below top of unit with a weathered-out nodule 20 cm long, cavity is filled with dark yellowish orange (10YR6/6) limonitic dust.....	26.6	1030.1
7.	Mudstone and clayshale (80 percent) with beds of siltstone (20 percent) up to 0.7 ft thick, predominantly less than 0.2 ft thick; unit 7 is gradational with overlying unit 8; siltstone content of unit 7 increases gradually upward. Mudstone and clayshale are dark gray (N3), weather medium dark gray (N4); finely micaceous; a few distinct horizontal burrows less than 7 mm wide occur in mudstone. Clayshale has faint textural lamination; parting is		

	Thickness (feet) Unit	Cum.
3 mm thick; locally slightly silty. Siltstone is medium gray (N5); beds commonly show Tc- Bouma sequences and rippled top surfaces; horizontal burrows less than 6 mm wide are common on top surfaces of some beds.....	53.5	1003.5
6. Covered. Thickness estimated geometrically from map location of outcrops, strike and dip data and altitude data measured with a surveying altimeter accurate to ± 3 ft....	430±	950.0

NOTE: Unit 5 is described at roadcut along old U.S. Highway 21-52, 0.2 mile east of its junction with the new U.S. Highway 21-52.

5. Clayshale (80 percent) with beds of siltstone (20 percent) up to 0.4 ft thick, modal bed thickness is 0.1 ft. Siltstone abundance ranges up to 40 or 50 percent in a few thin intervals. Shale is of two types; a light olive gray (5Y6/1) shale predominates in lower half of unit, and a grayish black (N2) shale predominates in upper half of unit; minor interbedding of these 2 shale types on a scale of a few centimeters occurs. Light olive gray shale weathers light olive gray (5Y5/2); shows textural lamination, and plane silt laminae up to 3 mm thick; minor color lamination up to 3 mm thick; a few distinct horizontal burrows up to 5 mm wide. Grayish black shale weathers dark gray (N3) to medium gray (N5); shows strong textural lamination and a few silt laminae less than 2 mm thick; minor bioturbation, which weathers yellowish gray (5Y8/1); parting thickness is less than 3 mm. At 56.4 feet above base of unit there is a 0.8 ft thick bentonite bed (sampled); weathers grayish orange (5Y5/7); less resistant than surrounding lithologies and very highly micaceous; mica flakes are silt and sand sized, and have a preferred orientation giving rock a textural lamination. Siltstone beds are sharply defined, persistent, and even; some

	Thickness (feet) Unit	Cum.
beds less than 0.1 ft thick show thickness variations because of rippled top surfaces; Tc- Bouma sequences predominate; a few sole markings, including hypichnial ridges, and groove and bounce molds, trending 228° at 38.5 ft above base of unit; hypichnial ridges are straight, non-branching forms, up to 7 mm wide and generally less than 7 cm long. Small thrust fault with several feet of displacement at 48 feet above base of unit. Top of unit 5 is 40 to 50 feet west of where power lines cross over road...	140.0	520.0
4. Covered. Thickness estimated geometrically from map locations of outcrops, strike and dip data, and altitude data obtained with a surveying altimeter accurate to ± 3 feet..	290±	380.0

NOTE: Units 1 through 3 are described at southwest facing outcrop on northeast side of U.S. Highway 21-52, at junction of U.S. Highway 21-52 and Virginia Route 615 in town of Bastian.

3. Clayshale, medium gray (N5), weathers light olive gray (5Y5/2); shows fine textural lamination; parting is 2 to 5 mm thick; a few horizontal burrows; at top of outcrop shale is more deeply weathered and light olive gray (5Y5/2) on freshest available surface; parting thickness also increases slightly upward.....	12.3	90.0
2. Siltstone (60 percent) in beds 0.1 ft to 3.1 ft thick, modal bed thicknesses of 0.1 and 0.7 ft with interbeds of clayshale (40 percent). Unit 2 was measured and described in bed by bed detail. Siltstone beds greater than 0.5 ft thick comprise 55 percent of unit. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); micaceous; beds are even, massive, and have flat sharp bases and generally sharp tops; top surfaces of a few beds are rippled; 65 percent of the siltstone beds show Ta- Bouma sequences, 19 percent show Tb- Bouma sequences, 8 percent show		

	Thickness (feet) Unit	Cum.
Tc- Bouma sequences, and 8 percent show Td-Bouma sequences; the unit ABC proximity index is 75 percent; rounded clay galls, typically several cm long, are common as are tiny carbonized wood fragments. Clayshale is medium dark gray (N3) to medium gray (N5), and weathers medium gray (N5) to light gray (N7); shows textural lamination; parting is 2 to 4 mm thick.....	23.2	77.7
Total Brallier Formation.....	3075.8	

Millboro Shale (incomplete):

1. Clayshale to mudshale, black (N1) at base of unit; becomes lighter in color and slightly upward; by 35 ft above base of unit shale is medium gray (N5); shale shows fine textural lamination throughout unit; Lingula found at 4.5 ft above base of unit; Layer of small calcite and siderite nodules at 32.9 ft above base; pinch and swell pyritic calcite layer 1.5 cm thick at 35.2 ft above base; siderite layers less than 0.1 ft thick occur at 34.0 ft, 39.5 ft, 40.0 ft, 49.3 ft, and 51.4 ft above base of unit. Small flexure of bedding between 35 and 45 ft above base of unit.	54.5	54.5
Total Millboro Shale (incomplete).....	54.5	

SECTION 23

Virginia Highway 16 Section

One of the more nearly complete sections of the Brallier Formation in southwest Virginia, exposed in a series of roadcuts along Virginia Highway 16, in Tazewell County (Tazewell South and Chatham Hill quadrangles). Section is described at many different outcrops because the exposures are discontinuous and as the highway meanders up Little Brushy Mountain it traverses both up and down section. The upper several hundred feet of the Brallier Formation and the "Chemung" Formation are very well exposed. The section begins at stratigraphically lowest exposures of shale, 0.15 mile east of where Virginia Highway 16 crosses over Laurel Fork Creek (453250 meters East, 4096300 meters North, Universal Transverse Mercator grid). Top of the section is 0.15 mile north of the crest of Little Brushy Mountain. Measured and described using Jacob's staff, Abney level, surveying altimeter, and tape by Paul D. Lundegard, September 4, 5, 6, and 7, 1978.

	Thickness (feet)	
Devonian (incomplete):	Unit	Cum.
"Chemung" Formation (incomplete):		
60. Siltstone, coarse-grained, and sandstone, very-fine-grained (80 percent) and mudstone (20 percent) in six thickening-upward sequences; each 5 to 10 ft thick; siltstone and sandstone beds are up to 0.2 ft thick in lower part of each sequence where they are generally plane laminated; and 0.6 to 1.0 ft thick at the top of each sequence where they are either plane laminated or show low-angle crossbedding; a few beds are fossiliferous; fossils include crinoid columnals, Spirifer sp. and Buchiola sp. brachiopods; a 0.6 ft thick sandstone bed at 23 ft below top of unit has curving inclined burrows in its upper part; one burrow resembles Cylindrichnus and is 20 cm long. Mudstone is olive gray (5Y4/1). Top of unit 60 is at culvert under road and cluster of four or five small locust trees 0.15 mile of mountain crest.....	50.8	2505.8
59. Siltstone, coarse-grained, and sandstone, very-fine-grained, in three massive beds with possible bed amalgamation. In the up-section direction these beds are 1.7 ft, 4.8 ft, and 2.2 ft thick, respectively;		

		Thickness (feet) Unit	Cum.
	each is medium gray (N5), weathers light olive gray (5Y6/1), shows faint plane lamination, and contains fossiliferous streaks; crinoid columnals are most abundant; other fossils include Camarotoechia sp., and unidentified brachiopod and pelecypod fragments.....	8.7	2455.0
58.	Siltstone, coarse-grained (50 percent), in beds 0.1 to 0.4 ft thick, modal bed thickness is 0.15 ft, with interbeds of mudstone (50 percent). Siltstone beds pinch and swell; some are discontinuous; beds are predominantly plane laminated; a very few imprints of Camarotoechia sp. Mudstone interbeds are dark gray (N3), and weather olive gray (5Y4/1).....	5.3	2446.3
57.	Siltstone, coarse-grained, a single bed but bed amalgamation is probable; medium gray (N5), weathers light olive gray (5Y6/1); faint plane lamination; several 1 to 2 cm thick fossiliferous streaks very rich in small crinoid columnals; a shale clast or remnant 2 cm thick and 23 cm long occurs locally at probable amalgamation surface. Two imbricate thrust faults, each with 1 to 2 feet of westward displacement cut this bed.....	1.9	2441.0
56.	Siltstone, coarse-grained, and sandstone, very-fine-grained (80 percent), in beds 0.1 to 0.8 ft thick, modal bed thickness is 0.15 ft, with interbeds of mudshale (20 percent). Individual siltstone and sandstone beds thicken and thin somewhat irregularly and show plane lamination or low-angle crossbedding; some beds are fossiliferous; shale clasts are common in the fossiliferous beds. Fossils are especially abundant in lower 4.0 ft of unit, and include abundant small crinoid columnals, Spirifer sp., Leiorhyncus sp. brachiopods, and Modiola (?), Nucula sp. pelecypods. Mudshale interbeds are dark		

		Thickness (feet) Unit	Cum.
	gray (N4), weather medium gray (N5) to olive gray (5Y4/1), and show weak textural lamination.....	9.1	2439.1
55.	Siltstone, coarse-grained, essentially a single bed with possible bed amalgamation; some faint plane lamination; a few straight, vertical burrows less than 5 mm wide in upper half of bed.....	3.3	2430.0
54.	Mudstone (60 percent) with indistinct beds of coarse-grained siltstone (40 percent) less than 0.2 ft thick. Mudstone is olive gray (5Y4/1), very silty, finely micaceous, and has hackly parting. Siltstone beds are medium gray (N5), weather light olive gray (5Y5/2); some beds show plane lamination; siltstone beds are distinguished from mudstone with difficulty.....	11.5	2426.7
53.	Siltstone, coarse-grained, single bed, olive gray (5Y4/1), weathers light olive gray (5Y5/2); massive; structureless.....	2.8	2415.2
52.	Siltstone, coarse-grained, in beds 0.15 to 0.5 ft thick with very minor interbeds of mudstone as in unit 54. Siltstone is medium gray (N5), weathers light olive gray (5Y6/1); finely micaceous; beds are either structureless or plane laminated; horizontal burrows are common on the top surfaces of beds; one inclined burrow with longitudinal striae; a few imprints of costate brachiopods.....	15.0	2412.4
51.	Covered. Probable small high angle fault. Stratigraphic thickness undertain but probably less than 10 feet.....	10.0	2397.4

NOTE: Units 46 through 50 comprise an overall thickening-upward and coarsening-upward sequence.

50.	Siltstone, coarse-grained, and sandstone, very-fine-grained, and mudstone in two thickening-upward sequences. Lower		

		Thickness (feet) Unit	Cum.
	thickening-upward sequence is 16.0 ft thick; upper 4.0 ft consists of fossiliferous, crossbedded sandstone in beds up to 1.3 ft thick, showing incipient ball and pillow structure, and clay chips at base of beds; beds in lower part of this sequence are predominantly less than 0.2 ft thick, with a maximum bed thickness of 0.5 ft. The second thickening-upward sequence is 18.6 ft thick and begins with approximately 70 percent siltstone in beds 0.15 to 0.3 ft thick, bed thickness increases upward with little change in the abundance of siltstone; a 2.1 ft thick coarse-grained siltstone occurs at the top of this sequence; siltstone beds are predominantly plane laminated. Mudstone interbeds are medium dark gray (N4), and weather olive gray (5Y4/1); finely micaceous; part with a hackly edge; commonly show distinct horizontal burrows less than 5 mm wide.....	34.6	2387.4
49.	Siltstone, coarse-grained, and sandstone, very-fine-grained (80 percent), in beds 0.2 to 0.9 ft thick, modal bed thickness is 0.3 ft, with interbeds of mudstone as in unit 50 (20 percent). Beds of siltstone and sandstone greater than 0.25 ft thick are distinctive of unit 50. Overall thickening-upward sequence; top 6 ft is 90 percent sandstone in beds 0.3 to 0.9 ft thick; beds are generally uneven; plane lamination and low-angle crossbedding are common; top surfaces of some beds show horizontal burrows; a few beds are fossiliferous, especially 0.5 ft thick siltstone at 5.0 ft above base; fossils include Camarotoechia sp. brachiopods and pelecypods (possibly Edmondia sp.).....	18.0	2352.8
48.	Mudstone as in unit 50 (85 to 90 percent) with beds of siltstone (10 to 15 percent) up to 0.1 ft thick, modal bed thickness is 2 cm. Siltstone beds appear to be predominantly structureless; a few beds show plane lamination or cross-lamination.....	7.5	2334.8

		Thickness (feet) Unit	Cum.
47.	Siltstone, coarse-grained, and sandstone, very-fine-grained (70 percent) in beds predominantly 0.15 to 0.6 ft thick, with interbeds of mudstone as in unit 50 (30 percent). Five or 6 siltstone and sandstone beds 0.3 to 0.6 ft thick are distinctive of unit 47. Siltstone and sandstone are medium gray (N5); most beds appear structureless; thickest beds are plane laminated, or show crossbedding in sets up to 0.6 ft thick; some beds pinch and swell. At base of unit there is a 0.6 ft thick, fossiliferous, coarse-grained siltstone bed; fossils concentrated at base of bed include Camarotoechia sp. brachiopods, and Nucula sp., Buchiola sp. pelecypods, and crinoid columnals.....	10.5	2327.3
46.	Sandstone, very-fine-grained, and siltstone, coarse-grained (95 percent at base of unit decreasing to 80 percent at top of unit), in beds 0.1 to 0.6 ft thick with interbeds of mudstone as in unit 50 (5 to 20 percent). Sandstone and siltstone are olive gray (5Y4/1); beds generally pinch and swell or are discontinuous; amalgamation of beds is common; sedimentary structures are difficult to observe in lower part of unit, but many beds appear plane laminated or cross-laminated; beds showing low-angle crossbedding in sets 7 to 16 cm thick are common in upper part of unit; vertical burrows with dark gray (N3) clayey fillings penetrate a few beds. Horizontal burrows are very common in mudstone interbeds.....	28.0	2316.8
	Total "Chemung" Formation (incomplete).	217.0	

Brallier Formation:

45.	Mudstone (75 percent) with beds of coarse-grained siltstone and very-fine-grained sandstone (25 percent) 0.15 to 1.3 ft thick. Mudstone is medium dark gray (N4), weathers olive gray (5Y4/1); finely		

		Thickness (feet) Unit	Cum.
	micaceous; hackly parting, distinct horizontal burrows less than 5 mm wide are common. Siltstone and sandstone are medium dark gray (N4) to olive gray (5Y4/1), weather light olive gray (5Y5/2); most beds pinch and swell or are discontinuous and show plane lamination or crossbedding in sets greater than 7 cm thick; crossbedding set thickness increases with bed thickness; groups of siltstone and sandstone beds 4.5 and 2.0 ft thick occur at the base of the unit and 14 feet above the base, respectively.....	25.4	2288.3
44.	Mudstone as in unit 45 (95+ percent in lower 30 ft of unit, decreases to 90 percent upward) with beds of siltstone to very-fine-grained sandstone (less than 5 percent in lower 30 ft, increases to 10 percent upward) predominantly less than 0.2 ft thick, modal bed thickness is less than 0.1 ft. Mudstone weathers spheroidally along several small high-angle faults with less than 2 ft of displacement; distinct horizontal burrows are common, and tend to weather light brown (5YR5/6); very few imprints of Camarotoechia sp. Siltstone and sandstone are medium gray (N5) to olive gray (5Y4/1); individual beds are of variable thickness or are discontinuous; internal structures are variable; plane laminated, cross-laminated and structureless beds all occur; partings are micaceous.....	44.6	2263.4
43.	Deformed zone probably bounded by high angle faults; consists of mudstone as in unit 45 and thin siltstone beds; offset of units 44 and 42 is unknown.....	30.0	2218.8
42.	Mudstone as in unit 45 (90 to 95 percent) with interbeds of siltstone (5 to 10 percent) up to 0.15 ft thick, predominantly less than 0.1 ft thick, modal bed thickness is 1 to 1.5 cm. Slight upward increase in		

		Thickness (feet) Unit	Cum.
	the thickness and abundance of siltstone beds. Siltstone beds are only slightly more resistant to weathering than mudstone interbeds.....	25.0	2188.8
41.	Covered at slight bend in road.....	12.0	2163.8
40.	Mudstone as in unit 45 (85 percent) with beds of siltstone to very-fine-grained sandstone (15 percent) up to 0.25 ft thick, modal bed thickness is less than 0.1 ft. Structures in siltstone and sandstone beds are not easily observed; plane lamination was noted in two beds.....	14.6	2151.8
39.	Siltstone, coarse-grained, olive gray (5Y4/1), in poorly defined structureless beds 0.2 to 0.7 ft thick; some amalgamation of beds. Unit 39 forms slight protrusion...	2.9	2137.2
38.	Mudstone as in unit 45 (60 percent) with beds of siltstone and very-fine-grained sandstone (40 percent) up to 0.25 ft thick, modal bed thickness is 0.15 foot. Siltstone and sandstone beds are predominantly structureless; a few beds are cross laminated; a few hypichnial ridges.....	7.5	2134.3
37.	Siltstone, coarse-grained, and sandstone, very-fine-grained (80 percent) in beds less than 0.1 ft to 0.4 ft thick, with interbeds of mudstone as in unit 45 (20 percent). Siltstone and sandstone beds are indistinct; thinnest beds are plane laminated or cross-laminated; other beds are structureless. Unit 37 protrudes over unit 36.....	3.5	2126.8
36.	Mudstone as in unit 45 (85 to 95 percent) with interbeds of siltstone (5 to 15 percent) up to 0.2 ft thick, modal bed thickness is less than 0.1 ft. Several indistinct beds of argillaceous siltstone in lower 7 ft of unit; distinct siltstone beds in remainder of unit show a mixture of Tc-, Tbc-, and Ta-Bouma sequences.....	40.9	2123.3

		Thickness (feet) Unit	Cum.
35.	Siltstone, coarse-grained, and sandstone, very-fine-grained, in beds 0.1 to 0.4 ft thick, medium gray (N5); essentially no fine-grained interbeds; sedimentation units are difficult to identify because of common amalgamation of beds; beds less than 0.1 ft thick are predominantly cross-laminated; thicker beds appear structureless or show irregular, discontinuous lamination.	17.6	2082.4
34.	Siltstone, very-fine-grained sandstone, and clayshale in an overall thickening- and coarsening-upward sequence, containing 5 smaller megasequences; the upper 2 clearly display coarsening- and thickening-upward trends. Siltstone and sandstone is medium gray (N5); beds are less than 0.1 to 0.3 ft thick; abundance ranges from less than 5 percent in lower 25 ft of unit to nearly 100 percent at top of unit; sole markings, mainly groove molds oriented 242° to 276° are common; Bouma sequences become more complete upward in the unit as a whole and in the upper 2 megasequences where Tbc and Tabc sequences are common; overall, siltstones with Tc- Bouma sequences, flat, sharp bases and rippled top surfaces predominate. Clayshale is dark gray (N3), weathers medium dark gray (N4); shows fine textural lamination; silt laminae less than 1 mm to 1 cm thick are locally common; minor horizontal bioturbation, weathering yellowish gray (5Y8/1); a few 1 to 2 cm thick, pinch and swell siderite layers in lower 25 ft of unit; siderite layers weather moderate brown (5YR4/4) and are structureless. Several small high angle faults with a few feet of displacement.....	138.0	2064.8
33.	Covered. Stratigraphic thickness estimated geometrically from map location of outcrops, strike and dip data, and altitude data obtained with a surveying altimeter accurate to ± 3 feet.....	46.0	1906.8

	Thickness (feet) Unit	Cum.
32. Clayshale (95 percent) with minor beds of siltstone (5 percent) up to 0.7 ft thick, modal bed thickness is 0.15 ft. Clayshale is brownish black (5YR2/1), weathers medium dark gray (N4); shows weak textural lamination; weathers to 5 to 10 mm thick chips; minor yellowish gray (5Y8/1) horizontal bioturbation. Siltstone beds predominantly show Tc- Bouma sequences and rippled top surfaces.....	90.0	1860.8

NOTE: There are additional exposures of dark shale with minor siltstone ~~inter~~beds similar to unit 32, both uphill and downhill from outcrop where unit 32 was described. Most of these exposures are repeated section and are folded and faulted. There is probably at least 150 ft of these dark shales with up to 20 percent siltstone in beds predominantly less than 0.3 ft thick, and up to 1.3 ft thick. An accurate thickness estimate is impossible because of structural deformation.

31. Covered. Thickness estimated with Jacob's staff and Abney level.....	50+	1770.8

NOTE: Units 18 through 30 are described along southwestern side of highway in 0.55 mile long straight stretch trending northwest-southeast Units 24 through 30 are generally not well exposed.

30. Claystone (80 percent) with beds of siltstone (20 percent) up to 1.0 ft thick, modal bed thickness is 0.15 ft. Claystone is medium gray (N5), weathers medium light gray (N6) to light gray (N7); strongly bioturbated; up to 100 percent bioturbated in some zones less than 0.5 ft thick; generally 30 to 60 percent bioturbated; burrows are indistinct and horizontal; weathers to subconchoidal chunks. Abrupt dip increase at top of unit. Top of unit is across highway from "Driver Subject to Arrest for Litter Thrown from Vehicle" sign.....	224.0	1720.8
29. Covered.....	26.0	1496.8
28. Mudstone to claystone (60 percent) with beds of siltstone (40 percent) up to 1.0 ft thick, modal bed thickness is 0.4 ft.		

		Thickness (feet) Unit	Cum.
	Slight decrease in proportion of siltstone upward. Mudstone and claystone are olive gray (5Y4/1) and weather light olive gray (5Y5/2); minor beds of dark gray (N3), bioturbated claystone.....	51.0	1470.8
27.	Mudstone as in unit 28 (95 percent) with minor beds of siltstone (5 percent) up to 0.15 ft thick.....	14.0	1419.8
26.	Mudstone as in unit 28 (70 percent) with beds of siltstone (30 percent) up to 1.8 ft thick, modal bed thickness is 0.2 ft. Siltstone bed thickness increases upward....	22.0	1405.8
25.	Poorly exposed; a few resistant beds of siltstone.....	33.0	1383.8
24.	Clayshale (45 percent) and claystone (10 percent) with beds of siltstone (45 percent) up to 2.0 ft thick, bed thickness is variable. Clayshale, is olive gray (5Y3/2), weathers light olive gray (5Y5/2) shows textural lamination; silt-free. Claystone occurs in one 4 ft zone, 5 ft above base of unit; shows intense indistinct horizontal bioturbation; unbioturbated portions are medium dark gray (N4), and weather medium gray (N5); bioturbated portions are medium light gray (N6) and weather light gray (N7) to yellowish gray (5Y8/1).....	30.0	1350.8
23.	Mostly covered with scattered small exposures of bioturbated light olive gray (5Y5/2) claystone, medium dark gray (N4) shale with minor bioturbation, and resistant siltstone beds up to 0.7 ft thick.....	297.2	1320.8
22.	Clayshale, grayish black (N2), weathers dark gray (N3) shows textural lamination; minor bioturbation; bioturbated portions weather yellowish gray (5Y8/1). One siltstone bed 0.8 ft thick in middle of unit.....	7.8	1023.6

		Thickness (feet) Unit	Cum.
21.	Covered.....	80.0	1015.8
20.	Siltstone, claystone, and clayshale; a single siltstone bed at base of unit, 0.8 ft thick; overlain by 1.2 ft of yellowish gray (5Y8/1), blocky claystone; in turn overlain by 3.0 ft of shale; shale is brownish black (5YR2/1), weathers medium dark gray (N4); shows textural lamination; minor yellowish gray (5Y8/1) weathering bioturbation.	5.0	935.8
19.	Covered.....	50.0	930.8
18.	Clayshale and claystone (95 percent) with minor beds of siltstone (5 percent) predominantly less than 0.2 ft thick. Clayshale predominates is lower 35 ft of unit; claystone predominates in upper 65 ft of unit. Clayshale is moderate olive brown (5Y4/4), weathers light olive gray (5Y5/2); shows textural lamination. Claystone is light olive gray (5Y5/2), and weathers light olive gray (5Y6/1).	95.0	880.8

NOTE: Units 10 through 17 are described along east side of the highway between hairpin turn at UTM grid location 453600 m East, 4096200 m North, and sharp turn at UTM grid location 453650 m East, 4095800 m North. In this interval downhill is upsection.

17.	Mudstone (95 percent) with minor beds of siltstone (5 percent) up to 0.3 ft thick, predominantly less than 0.2 ft thick. Mudstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); distinct horizontal burrows less than 5 mm wide are common. Siltstone beds show Tc- or Tbc- Bouma sequences. Five ft of section is covered at 12 ft below top of unit. Upper 20 ft of unit 17 may be equivalent to lower 20 ft of unit 18.....	57.0	785.8
16.	Covered.....	18.0	728.8
15.	Mudstone, olive gray (5Y4/1), weathers light olive gray (5Y5/2); hackly parting; distinct horizontal burrows less than 5 mm wide are common; spheroidal weathering in upper 3.0 ft of unit.....	13.0	710.8

		Thickness (feet) Unit	Cum.
14.	Claystone, weathers light gray (N7); intensely bioturbated; 90 percent bioturbated; indistinct subhorizontal burrows.....	4.0	697.8
13.	Clayshale, with a few siltstone beds less than 0.2 ft thick. Clayshale is olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; silt-free; minor horizontal bioturbation weathering yellowish gray (5Y8/1); a few distinct horizontal burrows weathering brownish.....	34.0	693.8
12.	Clayshale, black (N1), weathers grayish black (N2); fine textural lamination; fragments of carbonized wood up to 1.5 cm long are very abundant in lower 2.5 ft; bioturbation weathering yellowish gray (5Y8/1) in upper 2.0 ft. Two siltstone beds 0.3 and 0.2 ft thick, respectively.....	5.0	659.8
11.	Mudstone, pale brown (5YR5/2); blocky; a few black flecks of organic matter up to 3 mm long.....	0.8	654.8
10.	Mudstone (80 percent) and clayshale (15 percent) with minor beds of siltstone (5 percent) up to 0.4 ft thick, predominantly less than 0.1 ft thick. Mudstone and shale are moderate olive brown (5Y4/4), and weather light olive gray (5Y5/2); mudstone shows distinct horizontal burrows; clay-shale shows weak textural lamination and is slightly silty; at 16 ft above base of unit there is a 1.0 ft thick zone of mudstone which weathers grayish red (5R4/2) and spheroidally. Flexure of beds at 25 ft above base of unit. In upper 8.0 ft of unit, mudstone is more massive and intensely bioturbated; burrows weather moderate yellowish brown (10YR5/4). Siltstones predominantly show Tc- Bouma sequences.....	52.0	654.0
9.	Covered. Thickness estimated with Jacob's staff and Abney level.....	55.0	602.0

		Thickness (feet) Unit	Cum.
8.	Mudstone (85 percent) and shale (10 percent), with beds of siltstone (5 percent) up to 1.0 ft thick, predominantly less than 0.2 ft thick. Mudstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); resistant; forms flat, vertical faces; finely micaceous; parting is 5 to 10 mm thick or greater; distinct horizontal burrows up to 4 mm wide are abundant; bioturbation estimated at 30 percent. Shale is dark gray (N3) to black (N1), occurs in intervals up to 6 ft thick, and ranges from clayshale to mudshale; shows weak textural lamination; parting is 3 mm thick; blackish red (5R2/2) iron stain on parting surfaces. Siltstone beds are predominantly cross-laminated and have rippled top surfaces; two amalgamated beds 1.0 ft thick occur at 5 ft above base of unit.....	152.0	547.0
7.	Covered. With scattered small exposures of olive gray (5Y4/1) clayshale.....	70.0	395.0
6.	Clayshale, olive gray (5Y4/1), weathers light olive gray (5Y5/2); shows textural lamination; silt-free; parting is 3 mm thick; a few distinct horizontal burrows. Minor beds of grayish black (N2) clayshale weather medium gray (N5) to dark gray (N3); some bioturbation weathering yellowish gray (5Y8/1); a few tiny black flecks of organic matter. A few siltstone beds less than 0.2 ft thick.....	18.0	325.0
5.	Covered with scattered float of siltstone plates and grayish black (N1) shale as in unit 6.....	202.0	307.0
4.	Clayshale, grayish black (N2), as in unit 6. Claystone occurs where bioturbation is intense.....	22.0	105.0
3.	Covered with scattered, small exposures of grayish black (N2) shale as in unit 6.....	31.0	83.0

	Thickness (feet) Unit	Cum.
2. Claystone and minor clayshale with a very few siltstone beds less than 0.1 ft thick. Claystone is dark gray (N3), weathers medium gray (N5) to light olive gray (5Y5/2); bioturbated; bioturbated portions weather yellowish gray (5Y8/1); very finely micaceous; silt-free. Clayshale is same color as claystone; shows textural lamination and lacks significant bioturbation. Siltstone beds are cross-laminated, and have rippled top surfaces.....	7.0	52.0
Total Brallier Formation.....	2243.8	

Millboro Shale (incomplete):

1. Claystone and minor clayshale. Claystone is dark gray (N3), weathers medium gray (N5) to light olive gray (5Y5/2); minor bioturbation, weathering yellowish gray (5Y8/1); finely micaceous. Clayshale is same color as claystone; shows textural lamination and lacks significant bioturbation.....	45.0	45.0
Total Millboro Shale (incomplete).....	45.0	

SECTION 24

Broadford Section

Section of lower Brallier Formation, Millboro Shale, and complete section of Huntersville Chert exposed in roadcuts along Virginia Route 91 near its junction with Virginia Route 601, Broadford quadrangle, Tazewell County, Virginia (440000 meters East, 4089600 meters North, Universal Transverse Mercator grid). Base of section is 0.5 mile north of junction of Virginia Routes 91 and 601, at sharp bend in road. Top of section is 0.25 mile south of junction of Virginia Routes 91 and 601. Section measured, described and sampled using Jacob's staff, Abney level, surveying altimeter, and tape by Paul D. Lundegard, March 29 and 30, 1978.

Devonian (incomplete):		Thickness (feet)	
Brallier Formation (incomplete):		Unit	Cum.
18.	Mudstone (95 percent) with beds of siltstone (5 percent) 1 cm to 0.6 ft thick, modal bed thickness is 0.1 ft. Mudstone is olive gray (5Y4/1); shows hackly, subconchoidal parting 4 to 8 mm thick; hard and brittle. Siltstone is light olive gray (5Y6/1); beds highly weathered; some beds are indistinct from surrounding mudstone; 90 percent of beds show Tc- Bouma sequences; beds with rippled top surfaces are very common. At base of unit there is a 1.0 ft thick bed of claystone; moderate olive brown (5Y4/4), weathers light olive gray, parting is 5 to 10 mm thick.....	71.0	1453.0
17.	Covered. No indication of resistant beds...	93.0	1382.0
16.	Claystone and minor clayshale; both are dark gray (N3) to olive gray (5Y4/1), and weather medium dark gray (N4) to light olive gray (5Y6/1); color becomes more olive gray upward; minor yellowish gray (5Y8/1) weathering horizontal bioturbation; parting is 2 to 7 mm thick; some slicken-slides on bedding planes; clayshale shows faint textural lamination. Unit 16 is across road from "Maximum Safe Speed 20" sign.....	20.0	1289.0
15.	Mudstone (90 percent) with beds of siltstone (10 percent) up to 0.6 ft thick, modal bed thickness 0.1 ft. Mudstone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); micaceous; hackly parting 3 to 7 mm thick. Siltstone beds are predominantly cross-laminated; some beds are indistinct from surrounding mudstone.....	41.0	1269.0
14.	Covered. No indication of resistant beds...	11.0	1228.0
13.	Mudstone as in unit 15 (95 percent) with beds of siltstone (5 percent) up to 0.6 ft thick, modal bed thickness is 0.1 ft. Mudstone is most silty in middle of unit which forms slight protrusion. Siltstone		

		Thickness (feet) Unit	Cum.
	is olive gray (5Y3/2); beds are predominantly cross-laminated; 0.1 ft thick bed at 24 ft below top of unit is calcareous and weathers dark yellowish brown (10YR4/2). Calcareous nodule layer 0.1 ft thick at 26.5 ft above base of unit.....	69.0	1217.0
12.	Covered. No indication of resistant beds...	10.0	1148.0
11.	Mudstone as in unit 15. Silty nodule layer 0.1 ft thick at base of unit; weathers light brown (5YR5/6).....	15.0	1138.0
10.	Mudstone as in unit 15 with a very few indistinct siltstone layers less than 1 cm thick and one siltstone bed 0.3 ft thick in middle of unit.....	21.0	1123.0
9.	Covered. No indication of resistant beds...	18.0	1102.0
8.	Mudstone as in unit 15 with several siltstone beds up to 0.2 ft thick. Some fairly distinct horizontal burrows in mudstone. Middle of unit is across road from telephone pole.....	32.0	1084.0

NOTE: Units 6 and 7 are described in shale pit approximately 300 ft south of junction of Virginia Routes 91 and 601.

7.	Mudstone as in unit 15 (90 percent) with beds of siltstone (10 percent) up to 0.3 ft thick. Some horizontal burrows in mudstone.....	16.4	1052.0
6.	Claystone, olive gray (5Y4/1), weathers light olive gray (5Y6/1); slightly silty; finely micaceous; parting is 2 to 5 mm thick. Two beds of grayish black (N2) shale; a 0.3 ft thick bed at 7.6 ft above base of unit and a 0.8 ft thick bed at top of unit; both beds weather to a slight recess and show textural lamination; the upper bed also has a few silt laminae about 1 mm thick, immediately beneath this bed is 0.3 ft of highly bioturbated medium		

	Thickness (feet) Unit	Cum.
dark gray (N4) mudstone. Two siltstone beds 0.3 and 0.9 ft thick occur at 2.0 and 8.8 ft above base of unit, respectively; the lower siltstone bed is cross-laminated..	23.6	1035.6
5. Covered. Offset to exposures along Virginia Route 91, 0.25 mile north of its junction with Virginia Route 601, at sharp bend in road. Scattered exposures of dark gray (N3) clayshale and olive gray (5Y4/1) claystone. Thickness estimated from map locations and altitudes of outcrops and strike and dip data. Altitudes measured with surveying altimeter accurate to ± 3 feet.....	330+	1012.0
Total Brallier Formation (incomplete)..	771.0	

Millboro Shale:

4. Claystone, olive black (5Y2/1) to grayish black (N2), weathers medium gray (N5) to dark yellowish orange (10YR6/6); medium to strong bioturbation; bioturbated parts weather yellowish gray (5Y8/1); indistinct burrows are less than 2 mm wide and horizontal; some 2 to 3 mm thick yellowish gray biolaminae and streaks; faint textural lamination where bioturbation is less intense; bioturbation decreases in upper 3 ft; parting is 5 to 10 mm thick and hackly.....	17.0	682.0
3. Clayshale, grayish black (N2), weathers medium dark gray (N4), with a grayish red (5R4/2) iron stain on parting surfaces in lower 12 ft of unit; shows textural lamination throughout; parting is 2 to 5 mm thick in lower 30 ft and 5 to 10 mm thick in upper 26 ft of unit; phosphate (?) nodule layer 0.1 ft thick at 21.0 ft above base of unit; moderate reddish brown (10R4/6) layer of sticky clay 5 mm thick at 30.0 ft above base of unit.....	56.0	665.0

	Thickness (feet) Unit	Cum.
2. Covered. Thickness estimated from map locations of outcrops, strike and dip data, and altitude data obtained with a surveying altimeter accurate to ± 3 feet.....	565+	609.0
Total Millboro Shale.....	638.0	

Huntersville Chert:

1. Limestone, weathers medium gray (N5) to dark gray (N3); very cherty; highly fossiliferous; contains corals and brachiopods; beds are 0.2 ft to 7.5 ft thick; modal bed thickness is 0.7 ft; two glaconitic siltstone to very-fine-grained sandstone beds 0.2 and 0.4 ft thick occur at 8 ft above base of unit; limestone from 22.5 to 25.0 ft above base of unit is also glauconitic; covered zone 4.5 ft thick at 16.5 ft above base of unit.....	44.0	44.0
Total Huntersville Chert.....	44.0	

SECTION 25

Marion Section

Incomplete section of Brallier Formation including a siltstone bundle exposed in roadcuts along west side of Virginia Route 16, 0.4 mile south of Hungry Mother Lake dam, and 3.5 miles north of Marion, beneath high voltage power lines, Smyth County, Marion quadrangle, Virginia (452950 meters East, 4080100 meters North, Universal Transverse Mercator grid). Section is in lower one-third of Brallier Formation, beds are overturned slightly to the northwest. Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, March 27, 1978.

Devonian (incomplete):	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
6. Mudstone, olive gray (5Y4/1); indistinct horizontal burrows, hackly parting 2 to 5 mm thick.....	13.9	144.4

		Thickness (feet) Unit	Cum.
5.	Siltstone (75 percent) in beds up to 5.0 ft thick, modal bed thickness is 0.1 to 0.25 ft, 40 percent of beds are greater than 0.35 ft thick, interbeds are clayshale (25 percent). Unit 5 was measured and described in bed by bed detail. Siltstone is medium gray (N5), weathers light olive gray (5Y5/2); micaceous; evenly bedded; 59 percent of beds show Ta- Bouma sequences, 30 percent show Tb- Bouma sequences, and 11 percent show Tc- Bouma sequences; the unit ABC proximity index (Walker, 1967) is 74 percent; abundant sole markings with a mean trend of 266° include flute molds load casted flute molds, groove molds, ridge and furrow structure; hypichnial ridges resembling Paleophycus are very common; these trace fossils are 6 to 10 cm long, 8 to 10 mm wide and their ends taper into the bed; other sedimentary features include clay galls up to 20 cm in length concentrated near the base of beds, size grading, and tiny black wood fragments. Clayshale is dark gray (N3) to olive gray (5Y4/1), weathers medium gray (N5) to light olive gray (5Y5/2); shows textural lamination; finely micaceous; a few tiny black wood fragments; parting is 2 to 5 mm thick. Several very small high angle faults.....	44.7	130.5
4.	Clayshale, dark gray (N3), weathers medium dark gray (N4); shows textural lamination; parting is 2 to 3 mm thick. Two siltstone beds each 0.15 ft thick; one bed 4.4 ft below top of unit has sinusoidal lamination; the other bed at 15.6 ft below top of unit is plane laminated.....	27.8	85.8
3.	Clayshale (70 percent) with beds of siltstone (30 percent) 0.1 to 0.35 ft thick, modal bed thickness is 0.1 ft. Unit 3 was measured and described in bed by bed detail. Clayshale is dark gray (N3), weathers medium gray (N5); shows textural lamination;		

		Thickness (feet) Unit	Cum.
	locally slightly silty; parting is 2 to 5 mm thick; brittle. Siltstone is medium gray (N5); 7 percent of beds (one bed) show Tab- Bouma sequences, 71 percent show Tb- Bouma sequences, 11 percent show Tc- Bouma sequences, unit ABC proximity index (Walker, 1967) is 38 percent; abundant groove molds trending 288° to 308°; 0.1 ft thick siderite layer at base of unit.....	7.5	58.0
2.	Clayshale as in unit 3, with a few beds of siltstone (1 percent) up to 0.4 ft thick, modal bed thickness is 0.1 ft. Seventy-five percent of the siltstone beds are cross-laminated; groove mold at 10 ft below top of unit trends 266°.....	38.6	50.5
1.	Siltstone (75 percent) in beds 0.2 ft to 2.0 ft thick, with interbeds of clayshale as in unit 3 (25 percent). Siltstone beds are all somewhat fractured; two beds contain shale clasts.....	11.9	11.9
	Total Brallier Formation (incomplete)..	144.4	

SECTION 26

Richlands Section

Complete section of Cloyd Conglomerate Member of Price Formation and incomplete section of Brallier Formation. Only the uppermost Brallier Formation is exposed. Section exposed in ditch and hillside along old U.S. Highway 460, 0.4 mile west of Richlands High School, across highway from small brick utility shed, Tazewell County, Richlands quadrangle (430450 East, 4105200 North, Universal Transverse Mercator grid). Section measured and described with Jacob's staff, Abney level, and tape by Paul D. Lundegard, September 8, 1978.

	Thickness (feet)	
Mississippian (incomplete):		
Price Formation (incomplete):	Unit	Cum.
Cloyd Conglomerate Member:		
8. Sandstone, fine- to medium-grained; medium to thickly bedded; massive; quartz pebbles; crossbedding.....	23.0	116.1
Total Cloyd Conglomerate Member.....	23.0	
Devonian (incomplete):		
Brallier Formation (incomplete):		
7. Clayshale, dark gray (N3), weathers medium dark gray (N4); shows textural lamination; a few silt laminae less than 5 mm thick; grayish red (5R4/2) iron stain on parting surfaces. A few cross-laminated siltstones up to 0.1 ft thick.....	12.0	93.1
6. Siltstone, a single bed, dark gray (N3), argillaceous, resistant; consists of alternating medium gray (N5) silt laminae and streaks, and darker, more argillaceous siltstone; parting is 1 to 3 cm thick in lower 1.3 ft; middle 0.6 ft weathers to a recess.....	3.8	81.1
5. Mudstone, to mudshale with weak textural lamination; both are dark gray (N3); hackly parting is 2 to 5 mm thick; grayish red (5R4/2) iron stain on parting surfaces. A few 1 to 2 cm thick siltstone beds; plane laminated or low angle cross-lamination.....	6.0	77.3
4. Siltstone as in unit 6; weak irregular parting 1 to 3 cm thick; grayish red (5R4/2) iron stain on parting surface.....	2.3	71.3
3. Mudshale, dark gray (N3), weathers medium gray (N5); shows textural lamination; silt laminae and streaks 5 to 10 mm thick are common; some are internally plane laminated or cross-laminated; parting is 3 to 5 mm thick; grayish red (5R4/2) iron stain on parting surfaces. A few siltstone beds up to 0.2 ft thick but predominantly less		

		Thickness (feet) Unit	Cum.
	than 0.1 ft thick; slightly more numerous upward; sole marking noted on one bed. Upper half of unit is poorly exposed.....	36.0	69.0
2.	Clayshale (95 percent) with minor beds of siltstone (5 percent) up to 0.5 ft thick, modal bed thickness is 2 cm. Siltstone decreases in abundance towards middle of unit from both top and bottom. Clayshale is dark gray (N3), weathers medium gray (N5); shows textural lamination; silt laminae and streaks 0.5 to 7 mm thick are common; minor indistinct horizontal bioturbation; bioturbated zones yellowish gray (5Y8/1). Siltstone is micaceous; beds show Tc- and Tbc- Bouma sequences; 0.5 ft thick bed at 23 ft above base of unit contains abundant Lingula. Small, high angle fault of unknown displacement at base of unit next to culvert under highway..	30.0	33.0
1.	Siltstone (85 percent) in beds 0.1 to 0.4 ft thick with interbeds of mudshale (15 percent). Siltstone is medium gray (N5); micaceous; beds are plane laminated or cross-laminated. Mudshale is dark gray (N3), weathers medium gray (N5); shows textural lamination.....	3.0	3.0
	Total Brallier Formation (incomplete)..	93.1	

SECTION 27

Hayters Gap Section

Incomplete section of Brallier Formation exposed in roadcuts along Virginia Highway 80 and Virginia Route 689, Washington County, Hayters Gap quadrangle, Virginia. Base of section is in shale pit next to house along Virginia Route 689, 0.2 mile west of its intersection with Virginia Highway 80 (416800 meters East, 4077000 meters North, Universal Transverse Mercator grid). Top of section is at roadcut along Virginia Highway 80, 0.15 mile south of where it crosses Wolf Creek (417250 meters East, 4076400 meters North, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, March 31, 1978.

	Thickness (feet)	
Devonian (incomplete):		
Brallier Formation (incomplete):	Unit	Cum.
34. Mudstone (60 percent) and claystone (40 percent) with a few beds of siltstone predominantly less than 0.1 ft thick. Mudstone predominates in lower 2.5 ft of unit, claystone in upper 20 ft. Mudstone is dark gray (N3) to grayish black (N2), weathers medium dark gray (N4); parting is 5 to 10 mm thick; parting surfaces are smooth; scattered silt laminae 1 to 3 mm thick. Claystone is olive gray (5Y4/1), weathers light olive gray (5Y5/2); parting is 5 to 10 mm thick; partings are even to subconchoidal. Siltstone bed 0.2 ft thick at top of unit has groove mold trending 279°.	4.5	881.8
33. Siltstone, coarse-grained, and sandstone, very-fine-grained (75 percent), in beds 0.1 to 0.7 ft thick, modal bed thickness is 0.25 ft, with ~~inter~~beds of mudstone (25 percent) less than 0.2 ft thick. Siltstone and sandstone are olive gray (5Y4/1) to medium gray (N5); abundance is constant throughout unit; several beds are plane laminated. Mudstone is olive gray (5Y4/1) to dark gray (N3), weathers light olive gray (5Y6/1).....	18.1	877.3
32. Sandstone, very-fine-grained, single bed, medium gray (N5) to medium light gray (N6); even bedded; Ta- Bouma sequence, abundant		

		Thickness (feet) Unit	Cum.
	groove molds with a mean trend of 278°.....	1.4	859.2
31.	Claystone to mudstone (80 to 90 percent) with beds of siltstone (10 to 20 percent) less than 0.2 ft thick. Siltstone bed thickness and abundance increase upward. Claystone and mudstone are olive gray (5Y4/1) to black (N1), weather light olive gray (5Y5/2) to medium gray (N5); parting is 4 to 6 mm thick.....	7.5	857.8
30.	Siltstone (85 percent) in beds 0.2 to 0.3 ft thick with interbeds of clayshale (15 percent) predominantly less than 0.1 ft thick. Siltstone is evenly bedded; Ta- and Tb- Bouma sequences predominate. Clayshale is dark gray (N3); shows textural lamination; very slightly silty; parting is 2 to 5 mm thick.....	3.0	850.3
29.	Clayshale as in unit 30 with several beds of siltstone less than 0.1 ft thick.....	1.6	847.3
28.	Siltstone (90 percent) in beds 0.2 to 0.7 ft thick, with interbeds of clayshale as in unit 30 (10 percent) less than 0.1 ft thick. Siltstone is evenly bedded; 3 beds show Tb or Tbc Bouma sequences; 3 beds show Tc Bouma sequences.....	2.0	845.7
27.	Clayshale as in unit 30 (60 percent) with beds of siltstone (40 percent) 1 cm to 0.25 ft thick in a coarsening and thickening-upward sequence. Siltstone is medium gray (N5); micaceous; Tc- Bouma sequences predominate; groove molds on 0.25 ft thick bed at top of unit trend 274°.....	2.0	843.7
26.	Siltstone (80 percent) in 5 beds 0.1 ft to 1.2 ft thick, with interbeds of clayshale as in unit 30. Two 1.2 ft thick siltstone beds are distinctive of unit 26. Siltstone is evenly bedded; micaceous; 4 of the 5 beds show Ta- Bouma sequences.....	3.8	841.7

		Thickness (feet) Unit	Cum.
25.	Clayshale (80 percent) with beds of siltstone (20 percent) 1 cm to 0.25 ft thick. Clayshale is dark gray (N3), weathers medium gray (N5) to light olive gray (5Y6/1); shows textural lamination; silt-free; parting is 2 mm thick.....	3.4	837.9
24.	Sandstone, very-fine-grained, and siltstone, coarse-grained (95 percent), in uniformly thick beds up to 2.4 ft thick, separated by shale partings or thin shale interbeds (5 percent). Modal sandstone and siltstone bed thickness is 0.4 to 0.6 ft; 50 percent of beds are greater than 0.5 ft thick. Sandstone and siltstone are medium gray (N5); micaceous; evenly bedded; 80 percent of beds show Ta- Bouma sequences, 20 percent show Tb- Bouma sequences; content grading; load casts; 0.5 ft thick bed at 7.4 ft above base of unit has flute molds trending 267°.....	13.7	834.5
23.	Clayshale (75 percent) with beds of siltstone (25 percent) less than 0.1 ft to 0.6 ft thick. Clayshale is dark gray (N3); shows textural lamination; a few silt laminae less than 1 mm thick; locally slightly silty; parting is 2 to 5 mm thick. Siltstone is medium gray (N5); evenly bedded; abundant sole markings with a mean trend of 273°.....	8.7	823.0
22.	Siltstone, single bed, even, Tb- Bouma sequence, abundant flute and groove molds with a mean trend of 278°.....	0.8	812.1
21.	Mudshale (70 percent) with beds of siltstone to very-fine-grained sandstone (30 percent) less than 0.4 ft thick. Abundance and bed thickness of siltstone and sandstone decrease upward. Mudshale is black (N1), weathers medium dark gray (N4); shows textural lamination; parting is 2 mm thick; brittle. Siltstone and sandstone are medium gray (N5); 75 percent of beds show Tb-		

		Thickness (feet) Unit	Cum.
	Bouma sequences; sole markings at base of unit have a mean trend of 274°.....	10.5	811.3
20.	Clayshale (85 percent) with beds of siltstone (15 percent) up to 0.3 ft thick, predominantly less than 0.15 ft thick. Siltstone increases in abundance upward to 50 percent in upper 4.0 ft of unit. Clayshale is black (N1), weathers medium dark gray (N4) shows textural lamination; silt laminae less than 1 mm thick; parting is 2 mm thick; grayish red (10R4/2) iron stain on parting surfaces; brittle. Siltstone is medium gray (N5).....	8.5	800.8
19.	Siltstone and very-fine-grained sandstone (90 percent) in beds up to 1.4 ft thick, predominantly 0.3 to 0.6 ft thick, with thin interbeds of clayshale (10 percent) predominantly less than 0.2 ft thick. Siltstone and sandstone are evenly bedded; base of beds are flat and sharp; top of beds are gradational; groove molds 3.4 ft below top of unit trend 250°. Clayshale is grayish black (N2) to medium dark gray (N4), weathers medium dark gray (N4); shows textural lamination; silt laminae up to 1 mm thick are common.....	12.3	792.3
18.	Clayshale (80 percent) with 5 beds of siltstone (20 percent) less than 0.1 ft thick. Clayshale is grayish black (N2), weathers medium dark gray (N4); shows textural lamination; a few silt laminae less than 1 mm thick near base of unit; parting is 2 mm thick. Siltstone beds are all cross-laminated.....	1.4	780.0
17.	Sandstone, very-fine-grained, and siltstone (80 percent), in beds up to 1.1 ft thick, predominantly 0.1 to 0.6 ft thick, with interbeds of mudshale (20 percent). Sandstone and siltstone are medium gray (N5); 55 percent of beds show Tb- Bouma sequences, remainder show Tc- Bouma sequences. Mudshale		

		Thickness (feet) Unit	Cum.
	is medium dark gray (N4); shows textural lamination, parting is 2 to 5 mm thick.....	5.7	778.6
16.	Siltstone in 2 or more amalgamated beds; siltstone is medium gray (N5). Lowest bed is 0.8 ft thick, shows Tbc Bouma sequence, and is graded. Upper bed is 2.9 ft thick, shows Tab Bouma sequence, is graded, and is possibly 2 amalgamated beds.....	3.7	772.9
15.	Siltstone and very-fine-grained sandstone (70 percent) in beds 0.1 to 0.7 ft thick, with interbeds of clayshale (30 percent). Sixty percent of siltstone and sandstone beds show Tb- Bouma sequences; ripple crests at 1.4 ft below top of unit trend 300^{0}-120^{o} with current towards southwest; ball and pillow structure at 1.8 ft above base of unit. Clayshale is medium dark gray (N4); shows textural lamination; silt-free; parting is 5 to 10 mm thick.....	4.3	769.2
14.	Siltstone, coarse-grained, single bed, Tabc Bouma sequence, rippled top surface....	1.9	764.9
13.	Claystone (60 percent) with beds of siltstone (40 percent) up to 0.4 ft thick, predominantly 0.1 to 0.2 ft thick. Claystone is olive gray (5Y4/1), weathers medium gray (N5); parting is 3 to 5 mm thick. Siltstone is medium gray (N5); 90 percent of beds show Tc- Bouma sequences.....	3.2	763.0
12.	Covered.....	480 ±	759.9

NOTE: Units 7 through 11 are described at exposure on north side of Virginia Route 689, 200 ft west of church at junction of Virginia Routes 689 and 80.

11.	Mudstone, olive gray (5Y4/1); hackly parting 5 to 10 mm thick, some distinct horizontal burrows 3 to 5 mm wide.....	3.5	279.8

		Thickness (feet) Unit	Cum.
10.	Siltstone, coarse-grained, single even bed, base is sharp, Tab Bouma sequence, groove molds trending 245° and 254° , calcitic.....	0.7	276.3
9.	Claystone, highly weathered, light gray (N7), irregular parting is greater than 10 mm thick, blackish red (5R2/2) iron stain on parting surfaces, probably strongly bioturbated.....	1.7	275.6
8.	Mudstone with several beds of siltstone 1 to 3 cm thick. Mudstone is medium dark gray (N4), weathers medium gray (N5); very silty; hackly parting is 5 to 10 mm thick; brittle. Siltstone is medium gray (N5); beds are plane laminated; one calcitic bed, 0.2 ft thick at 3.0 ft above base, weathers pale brown (5YR5/2).....	6.0	273.9
7.	Mudstone with 3 or 4 beds of siltstone, 0.1 to 0.6 ft thick. Mudstone is dark gray (N3), weathers medium gray (N5); hackly parting is greater than 7 mm thick, grayish red (5R4/2) iron stain on parting surfaces; brittle. Siltstone is medium gray (N5), calcitic; 0.6 ft thick bed, 3.1 ft below top of unit, overlies a 0.5 ft thick bed of dark gray (N3) fissile shale with textural lamination.....	8.0	267.9

NOTE: Unit 6 is described along crest of northwest trending ridge, beginning behind church at junction of Virginia Routes 80 and 689, and continuing northwest towards shale pit on north side of Virginia Route 689, 0.2 mile from same junction.

6. Mudstone and claystone; scattered exposures; approximately 50 percent of unit is well exposed, remainder is inferred to be of similar lithology from examination of float chips and absence of resistant beds. Mudstone and claystone are olive gray (5Y4/1), weather light olive gray (5Y5/2); finely micaceous; a few indistinct horizontal burrows, parting is 2 to 10 mm thick;

		Thickness (feet) Unit	Cum.
	brittle; some float chips of dark gray (N3) shale in 5 ft interval 35 ft below top of unit; 0.4 ft thick siltstone bed at 61 ft below top of unit, bed is laminated and has flute and groove molds.....	148.0	259.9
5.	Covered.....	79.8	111.9
	Total Brallier Formation (incomplete)..	849.7	

Millboro Shale (incomplete):

NOTE: Units 1 through 4 are described at shale pit above Virginia Route 689, 0.2 mile west of its intersection with Virginia Route 80. A small reverse fault dips 55° to the southeast and repeats units 2, 3, and 4. Units 1 through 4 are described on lower block of fault. Exposures are very fresh.

4.	Claystone (90 percent) and clayshale (10 percent). Claystone is dark gray (N3), weathers medium dark gray (N4); subconchoidal bedding fracture; weathers to small angular chips. Two beds of black (N1) clayshale, each 0.4 ft thick at 1.8 and 6.3 ft above base of unit show textural lamination and are more resistant than claystone. Indistinct siltstone bed, 0.2 ft thick, at base of unit, weathers yellowish gray (5Y8/1); plane laminated or cross-laminated; alternating silty and clayey laminae. Several beds of light-weight, yellowish gray (5Y8/1) weathering clay (?), 0.1 to 0.2 ft thick; possibly highly weathered siderite layers or bentonites.....	8.4	32.1
3.	Interbedded clayshale (60 percent) and claystone (40 percent). Clayshale is black (N1), weathers grayish black (N2); shows textural lamination; more resistant than claystone beds; parting is 5 to 10 mm thick. Claystone weathers medium light gray (N6); parting is greater than 10 mm thick.....	4.0	23.7

	Thickness (feet) Unit	Cum.
2. Claystone, dark gray (N3), weathers to medium dark gray (N4) subconchoidal chips 10 mm thick.....	9.5	19.7
1. Interbedded clayshale (60 percent) and claystone (40 percent). Clayshale and claystone as in unit 3. Several silt laminae 1 to 10 mm thick in claystone in upper 1.5 ft of unit. Black clayshale beds are 0.5 ft to 2.2 ft thick, and more resistant than claystone. Gray claystone beds are 0.5 to 0.8 ft thick..	10.2	10.2
Total Millboro Formation (incomplete)...	32.1	

SECTION 28

Robinette Gap Section

Incomplete section of Brallier Formation exposed along Virginia Route 856 in Robinette Gap, 0.3 mile south of Virginia Route 802, Washington County, Wallace quadrangle, Virginia (389650 meters East, 4066000 meters North, Universal Transverse Mercator Grid). Bedding strikes 65 degrees northeast and dips 34 degrees southeast. At Wooten Gap, 1.6 miles to the northeast, Bartlett and Webb (1971, p. 66-67) identified "Chemung" fossils below the Cloyd Conglomerate Member of the Price Formation, in the interval here called Brallier Formation. Section measured and described using Jacob's staff, Abney level, and tape by Paul D. Lundegard, September 9, 1978.

Mississippian (incomplete):	Thickness (feet) Unit	Cum.
Price Formation (incomplete):		
4. Cloyd Conglomerate Member.....	27.4	60.9
Devonian (incomplete):		
Brallier Formation (incomplete):		
3. Mudshale to mudstone (80 percent) with beds of siltstone (20 percent, increases to 80 percent in upper 3.2 ft) less than 0.1 to 0.5 ft thick; mudshale and mudstone are dark gray (N3), weather medium gray (N5);		

		Thickness (feet) Unit	Cum.
	mudshale shows weak textural lamination. Siltstone is medium gray (N5); a few beds weather pale red (10R6/2) and are probably sideritic; beds have flat, sharp bases and undulatory top surfaces; several beds show plane lamination at base which becomes undulatory upward; one bed shows cross-bedding. Unit 3 is in slightly gradational contact with the overlying Cloyd Conglomerate.	22.0	40.0
2.	Mudstone, dark gray (N3), weathers pale brown (5YR5/2); very silty; forms a resistant protrusion. At base of unit there is a 0.4 ft thick bed of ferruginous, coarse-grained sandstone with quartz pebbles up to 10 mm in diameter.....	6.5	18.0
1.	Mudstone to mudshale, dark gray (N3), weather medium dark gray (N4); brittle; mudshale shows weak textural lamination; a few indistinct siltstone beds 1 to 2 cm thick; 11 structureless siderite nodule layers less than 0.2 ft thick occur in lower 10 ft of unit, these weather light brown (5YR5/6) to grayish red (5R4/2).....	11.5	11.5
	Total Brallier Formation (incomplete)...	40.0	

SECTION 29

Hilton's Section

Upper part of Brallier Formation, "Chemung" Formation (?), and Cloyd Conglomerate Member of the Price Formation exposed in roadcuts and in shale pit near Hiltons, Scott County, Hilton quadrangle, Virginia. Base of section is in shale pit, south side of U.S. Highway 421, across from "Clark's Food Market" and "Shell" station (368800 meters East, 4057150 meters North, Universal Transverse Mercator grid). Units 1 through 5 are described in this shale pit. Units 7 through 13 are described at roadcuts along Virginia Route 709, paralleling Hilton Creek, in Hilton Gap. Top of section is 600 ft northwest of the junction of Virginia Route 709 and U.S. Highway 421

(369450 meters East, 4056850 meters North, Universal Transverse Mercator grid). Section measured, described, and sampled using Jacob's staff, Abney level, surveying altimeter and tape by Paul D. Lundegard, September 9, 1978.

	Thickness (feet) Unit	Cum.
Mississippian (incomplete):		
Price Formation (incomplete):		
Cloyd Conglomerate Member:		
13. Sandstone, fine- to very-fine-grained (95 percent) in beds 0.1 ft to 1.5 ft thick with minor interbeds of clayshale (5 percent) less than 0.1 ft thick. Sandstone is dark gray (N3); beds pinch and swell or discontinuous; low angle cross-bedding. Clayshale is dark gray (N3); shows textural lamination.....	12.3	647.3
Total Cloyd Conglomerate Member.....	12.3	
Total Price Formation (incomplete)....	12.3	
Devonian (incomplete):		
"Chemung" Formation (?):		
12. Sandstone, very-fine-grained (60 percent) in beds 0.1 to 0.4 ft thick, with ~~interbeds~~ of mudstone (40 percent). Sandstone is medium gray (N5); beds pinch and swell or discontinuous; beds show predominantly plane and undulatory lamination; cross-lamination at tops of beds; a few sole markings; groove mold trends 270°; 0.4 ft thick bed at base of unit is strongly bioturbated; individual burrows up to 1 cm wide. Mudstone is dark gray (N3), silt laminae up to 5 mm thick are locally common; yellowish gray (5Y8/1) biolamination and streaks up to 3 mm thick. Siderite nodule layers up to 0.1 ft thick occur at 1.6 ft, 2.5 ft, and 10.0 ft above base of unit; nodules have concentric structure and weather light brown (5YR5/6).....	13.0	635.0
Total "Chemung" Formation (?).....	13.0	

Brallier Formation (incomplete):	Thickness (feet) Unit	Cum.
11. Mudstone, dark gray (N3) weathers medium gray (N5) to olive gray (5Y4/1); grouped and individual silt laminae up to 5 mm thick are common, especially in middle 10 ft of unit; yellowish gray (5Y8/1) biolamination and streaks up to 3 mm thick, more abundant in middle 10 ft of unit where bioturbation reaches 20 to 40 percent. Plane laminated siltstone bed 0.1 ft thick at 5 ft above base of unit; two 0.25 ft thick siltstone beds in upper 2.0 ft of unit; pinch and swell to discontinuous; show cross-lamination and fine groove molds. Siderite nodules 5 ft below top of unit.....	28.0	622.0
10. Mudstone (90 percent) with beds of siltstone (10 percent) up to 0.25 ft thick, modal bed thickness 0.2 ft. Mudstone is dark gray (N3), weathers olive gray (5Y4/1); parting is 5 mm thick. Siltstone is dark gray (N3); beds have sharp, flat bases; show Tb or Tbc Bouma sequences; some beds show rippled top surfaces. Unit 10 forms resistant protrusion from outcrop.....	8.5	594.0
9. Clayshale with a few beds of siltstone (1 percent) up to 0.1 ft thick. Clayshale is dark gray (N3) to olive gray (5Y4/1), weathers light olive gray (5Y6/1) to olive gray (5Y4/1); shows textural lamination; silt laminae less than 1 mm thick are common; minor yellowish gray (5Y8/1) bioturbation occurring as diffuse reworked zones and biolaminae and streaks up to 1 mm thick; silt laminae and bioturbated portions are dark yellowish orange (10YR6/6) on fresh surfaces; parting is 3 to 5 mm thick. Siltstone beds show Tbc and Tc Bouma sequences, and rippled top surfaces; 8 to 10 siltstone beds in lower 10 ft of unit. Six siderite nodule layers up to 0.1 ft thick occur in upper 7 ft of unit; nodules weather grayish red (5R5/2).....	45.5	585.5
8. Covered.....	100.0	540.0

		Thickness (feet) Unit	Cum.
7.	Clayshale as in unit 9 with a few beds of siltstone and very-fine-grained sandstone (1 percent) less than 0.1 ft thick. Siltstone and sandstone beds show Tc Bouma sequences and rippled top surfaces. Siderite nodule 2 cm thick at 21.5 ft above base of unit weathers light brown (5YR5/6). Base of unit is opposite cinder block building next to white house.....	40.0	440.0
6.	Covered. Thickness estimated geometrically from map location of outcrops, strike and dip data and altitude data obtained with a surveying altimeter accurate to ± 3 feet. Offset to shale pit above U.S. Highway 421 across from "Clark's Food Market" and "Shell station".....	140.0	400.0
5.	Clayshale to mudshale, olive gray (5Y4/1) to dark gray (N3), weathers light olive gray (5Y5/2); shows textural lamination; silt laminae up to 2 mm thick are common and comprise 30 percent of several intervals 0.2 ft to 1.2 ft thick and 50 percent of one 5 ft thick interval 50 ft below top of unit; weakly bioturbated in upper 60 ft of unit; diffuse yellowish gray (5Y8/1) burrow mottling, biolamination and streaks up to 3 mm thick.....	112.0	260.0
4.	Claystone and shale as in unit 5. Claystone is olive gray (5Y4/1) to dark gray (N3), weathers light olive gray (5Y5/2); 10 to 80 percent bioturbation as in unit 5; thin layers up to 2 cm thick are completely bioturbated; silt laminae up to 1 mm thick are very common; 5 siderite layers and nodule layers 1 to 2 cm thick in middle of unit.....	50.0	145.0
3.	Clayshale, olive gray (5Y4/1) to dark gray (N3) weathers light olive gray (5Y5/2); shows textural lamination; a few silt laminae up to 1 mm thick; very minor yellowish gray (5Y8/1) bioturbation as in		

		Thickness (feet) Unit	Cum.
	unit 5. Eleven siderite layers and nodule layers 1 to 2 cm thick; nodules weather light brown (5YR5/6) to pale reddish brown (10R5/2).....	34.0	98.0
2.	Clayshale as in unit 3 with more abundant bioturbation; bioturbation reaches 10 percent; biolaminae 1 to 5 mm thick are common; many are slightly silty. Several highly weathered siderite layers 1 cm thick in middle of unit.....	20.0	64.0
1.	Clayshale, medium dark gray (N4) to olive gray (5Y4/1), weathers medium light gray (N6) to light olive gray (5Y6/1); shows textural lamination; silt laminae up to 2 mm thick are common, and tend to occur in groups. Several siderite layers and nodule layers, 1 to 2 cm thick in lower half of unit; some are highly weathered to a dark yellowish orange (10YR6/6) punky material and form recesses in outcrop.....	44.0	44.0
	Brallier Formation (incomplete).....	622.0	

SECTION 30

Nottingham Section

Incomplete section of Brallier Formation exposed in shale pit on southeast side of U.S. Highway 421-58, 0.1 mile northwest of "Flanary's Grocery", and 0.7 mile northeast of Virginia Route 614, Scott County, Gate City quadrangle, Virginia (365200 meters East, 4055750 meters North, Universal Transverse Mercator Grid system). Section is of the upper part of the Brallier Formation at the tip of a tongue-like topographic ridge extending northwest from Pine Ridge. Pine Ridge is formed by Mississippian sandstones of the Price Formation. Section measured and described using Jacob's staff, Abney level, and tape by Paul D. Lundegard, July 18, 1978.

Devonian (incomplete):

	Thickness (feet) Unit	Cum.
Brallier Formation (incomplete):		
1. Claystone to clayshale, both are olive gray (5Y4/1) to dark gray (N3), and weather light gray (N7) to grayish orange (10YR7/4); a few silt laminae up to 1 mm thick; weakly to strongly bioturbated; bioturbation averages approximately 20 percent; clayshale shows textural lamination and is less bioturbated than claystone; bioturbation is horizontal; individual burrows are generally not recognizable; bioturbated zones weather yellowish gray (5Y8/1); some completely reworked zones up to 0.15 ft thick; abundant biolamination and streaks. No beds of siltstone.....	165.0	
Total Brallier Formation (incomplete)....		165.0

SECTION 31

Cowan Gap Section

The Price Formation, including the Greendale and Ceres Members (following the usage of Bartlett, 1974) is exposed in railroad cuts about fifty yards west of where Virginia Route 636 passes under the railroad tracks, Scott County, Church Hill quadrangle, Virginia (348900 meters East, 4053900 meters North, Universal Transverse Mercator Grid). Section measured and described using Jacob's staff, Abney level, and tape by Paul D. Lundegard, September 9, 1978.

Mississippian (incomplete):

	Thickness (feet) Unit	Cum.
Price Formation (incomplete):		
Greendale Member (incomplete):		
10. Sandstone, thick bedded, massive. Not measured or described in detail.		
9. Sandstone, very-fine-grained (80 percent, but difficult to estimate), in beds less than 0.1 ft to 0.25 ft thick with interbeds of mudstone (20 percent). Sandstone and mudstone are difficult to distinguish because there is little weathering difference between them. Sandstone is medium gray		

	Thickness (feet) Unit	Cum.
(N5); beds are pinch and swell or discontinuous; parallel laminated or with slightly disturbed lamination. Mudstone is dark gray (N3) and very silty.....	1.6	78.5
8. Sandstone, very-fine-grained, single bed, medium gray (N5), plane laminated, massive..	1.6	76.9
Total Greendale Member (incomplete)....	3.2	

Ceres Member (incomplete):

7. Mudstone to non-bedded argillaceous siltstone (70 percent) with distinct beds of coarse-grained, to very-fine-grained sandstone (30 percent) up to 0.1 ft thick. Mudstone and nonbedded siltstone are dark gray (N3). Siltstone and sandstone beds are predominantly plane laminated or have irregular horizontal lamination. Siderite nodule layer, 0.1 ft thick, in middle of unit.....	5.3	75.3
6. Sandstone, very-fine-grained, two massive beds separated by a shale parting; lower bed is 2.5 ft thick and medium dark gray (N4); upper bed is 0.8 ft thick and medium light gray (N6).....	3.3	70.0
5. Mudshale, to mudstone; both are dark gray (N3) parting is 3 to 6 mm thick; blackish red (5R2/2) iron stain on parting surfaces; rare silt laminae less than 1 mm thick. Mudshale shows weak textural lamination. Siderite nodules up to 1.6 ft in long dimension are scattered throughout unit. One 0.1 ft thick, plane laminated siltstone bed, 1.0 ft below top of unit.....	9.7	66.7
4. Sandstone, very-fine-grained, in beds 0.1 to 0.4 ft thick, sideritic, plane laminated or with slightly disturbed horizontal lamination. Minor dark gray (N3) mudshale in lower half		

		Thickness (feet) Unit	Cum.
	of unit. At top of unit there is a 0.9 ft thick, ferruginous, fine-to coarse-grained sandstone with abundant quartz pebbles, capped by a 0.1 ft thick undulatory siderite layer.....	4.6	57.0
3.	Mudshale to mudstone, dark gray (N3), some silt laminae less than 1 mm thick; mudshale shows textural lamination; many uneven siltstone beds (10 percent), 1 to 3 cm thick, with irregular lamination.....	1.4	52.4
2.	Siltstone, coarse-grained, 2 or 3 beds, each of variable thickness, medium dark gray (N4); lowermost bed is 0.7 ft thick and shows low-angle cross bedding. Minor mudshale interbeds.....	1.2	51.0
1.	Clayshale to mudshale (greater than 90 percent) with minor beds of siltstone to very-fine-grained sandstone (less than 10 percent) up to 0.15 ft thick. Abundance of siltstone and sandstone decreases upward from less than 5 percent in lower 15 ft to 10 percent in upper 10 ft. Shale is olive gray (5Y4/1); silt content increases upward; shows textural lamination; a few silt laminae less than 1 mm thick; parting is 3 to 5 mm thick; very minor yellowish gray (5Y8/1) bioturbation. Siltstone and sandstone are medium gray (N5); in lower 15 ft beds are less than 0.1 ft thick and predominantly plane laminated; in upper 10 ft beds are pinch and swell to discontinuous, and some beds show plane lamination which becomes undulatory upward. Siderite nodule layers less than 0.1 ft thick occur at 15, 18, 38.5, and 42 ft above base of unit....	49.8	49.8
	Total Ceres Member (incomplete).....	52.4	
	Total Price Formation (incomplete)...	78.5	

SECTION 32

Little War Gap Section

Nearly complete section of gray silty shale unit of Chattanooga Shale in roadcuts on the west side of Tennessee Highway 70, Hawkins County, Camelot quadrangle, Tennessee, (318550 meters East, 4040500 meters North, Universal Transverse Mercator Grid). Exposures are of low knobs in Poor Valley across highway from Klepper Chapel. Section begins at farm gate next to barn and continues to the south. Top of section is about 30 feet north of curve warning sign. Highway is oblique to the strike of bedding. Measured, described and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard on July 17, 1978, and its radioactivity profile measured using scintillometer by Paul D. Lundegard and Greg Hinterlong, November 10, 1978.

Devonian:	Thickness (feet)	
Chattanooga Shale (incomplete):	Unit	Cum.
11. Mudshale and nonbedded siltstone. Mudshale is dark gray (N3), weathers medium gray (N5), shows textural lamination; thin silt laminae less than 1 mm thick are common; platy parting 2 to 10 mm thick with a modal thickness of 5 mm. Non-bedded siltstone is plane laminated and very similar to the mudshale but has a greater silt content. Unit becomes less silty upward. Upper three fourths of unit are more deeply weathered and freshest color is olive gray (5Y4/1), weathered color is yellowish gray (5Y7/2). Top of unit is 30 ft north of curve warning sign.....	85.0	400.0
10. Siltstone, medium gray (N5), nonbedded, platy, plane laminated, individual laminae are less than 1 mm thick and even; parting is 3 to 10 mm thick and even. Unit 10 forms crest of knob.....	13.5	315.0
9. Mudshale, dark gray (N3), weathers medium gray (N5), shows textural lamination; silt laminae less than 1 mm thick are very common; even, plane laminated silt layers less than 5 mm thick are also common, parting is 3 mm thick and even.....	13.5	301.5

		Thickness (feet) Unit	Cum.
8.	Clayshale with 28 or more sideritic siltstone layers 1 to 2.5 cm thick. Clayshale is dark gray (N3), weathers medium gray (N5), shows faint textural lamination; generally non-silty; a few silt laminae less than 1 mm thick; parting is 3 to 5 mm thick. Sideritic siltstone layers are dark yellowish brown (10YR4/1), weather dark yellowish orange (10YR6/6), structureless; beds commonly of variable thickness and difficult to trace laterally. At road level, top of unit 8 is directly below crest of knob.....	58.4	288.0
7.	Mudshale, dark gray (N3), weathers medium light gray (N6) to light olive gray (5Y6/1); shows textural lamination and variable amounts of even silt laminae less than 1 mm thick; disseminated silt content increases upward and shale becomes harder and more brittle; parting is 5 to 10 mm thick. There is gentle folding of the beds in this unit. Base of unit is at beginning of long, continuous exposure of low knob....	99.6	229.6
6.	Covered.....	44.4	130.0
5.	Clayshale, deeply weathered, pale yellowish brown (10YR6/2) to pale brown (5YR5/2), weathers light olive gray (5Y6/1); finely micaceous; shows faint textural lamination; a few silt laminae less than 1 mm thick; faint moderate brown (5YR4/4) color lamination associated with some silt laminae; minor disseminated silt; parting is 1.5 to 3.0 cm thick.....	5.6	85.6
4.	Covered.....	9.0	80.0
3.	Clayshale as in unit 5; upper 2.0 ft of unit is mudshale with abundant even silt laminae less than 1 mm thick; minor amounts of bioturbation. Unit 3 is described in ditch along northwest side of road.....	16.0	71.0

		Thickness (feet) Unit	Cum.
2.	Covered.....	50.0	55.0
1.	Mudshale to clayshale, as in unit 5.....	5.0	5.0
	Total Chattanooga Shale (incomplete).	390.0	

SECTION 33

Flat Gap Section

Nearly complete section of gray silty shale unit of Chattanooga Shale exposed in roadcut along east side of Tennessee Route 31, 4.3 miles north of its junction with U.S. Highway 11-W, Lee Valley quadrangle, Hawkins County, Tennessee (300700 meters East, 4030450 meters North, Universal Transverse Mercator Grid). Base of section is 75 ft south of where culvert passes under road. Provo, Kepferle, and Potter (1977, p. 46) described the Chattanooga Shale at this locality, and Hasson (1972) described the Mississippian Grainger Formation and uppermost Chattanooga Shale. Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, July 12 and 13, 1978, and its radioactivity profile measured using scintillometer by Paul D. Lundegard and Greg Hinterlong, November 11, 1978.

Mississippian (incomplete):

Grainger Formation (incomplete):

Basal siltstone member; not measured or described.

Devonian (incomplete):

Chattanooga Shale (incomplete):

21. Clayshale (95 percent) with beds of siltstone (5 percent) up to 0.2 ft thick. Siltstone increase in abundance upward. Clayshale is dark gray (N3), weathers medium gray (N5) to medium light gray (N6); shows textural lamination; parting is 2 to 5 mm thick; a few siderite (?) nodules weathering light brown (5YR5/6). Siltstone is medium light gray (N6), weathers light gray (N7) light

		Thickness (feet) Unit	Cum.
	brown (5YR5/6) iron stain in places; micaceous; tiny specks of dark organic matter; beds have sharp basal contacts and slightly gradational top contacts; Tab Bouma sequences; a few sole markings in upper 15 ft of unit. Provo, Kepferle, and Potter (1977, p. 47) measured flute molds in this unit trending 244°, with blunt ends toward east.....	92.1	575.3
20.	Covered.....	43.0	483.2
19.	Clayshale, brownish black (5YR2/1) to black (N1), weathers medium dark gray (N4); shows textural lamination; slightly silty; parting is 5 to 10 mm thick. Unit 19 is described in creek bed 15 ft northeast of culvert under road.....	6.0	440.2
18.	Covered.....	94.0	434.2
17.	Siltstone, light olive gray (5Y6/1), weathers medium gray (N5) to light olive gray (5Y6/1); some light brown (5YR5/6) iron stain on surface; non-bedded and generally shows no lamination; strongly bioturbated; parting is irregular and 5 to 10 mm thick...	10.4	340.2
16.	Covered.....	67.5	329.7

NOTE: Units 1 through 15 comprise an overall thickening- and coarsening-upward sequence.

15. Sandstone, fine-grained, to siltstone, medium light gray (N6) to dark gray (N3); indistinctly bedded; sedimentation units are not recognizable; structureless or having black, clayey laminae or streaks which are uneven, and discontinuous; highly bioturbated with distinct curving and branching horizontal burrows less than 5 mm wide observable on some parting surfaces; these burrows resemble Scalarituba but lack the transverse scaliform ridges of that genus; irregular, bumpy partings, 1 to

		Thickness (feet) Unit	Cum.
	5 cm thick; bedding strikes 68 degrees northeast, and dips 56 degrees southeast into fault plane at top of unit.....	27.0	262.2
14.	Sandstone, very-fine-grained, and siltstone, medium light gray (N6) to dark gray (N3); indistinctly bedded as in unit 13 but more massive; the most prominent and persistent partings are spaced 1 to 3 ft apart with spacing increasing upward in unit; parting surfaces are irregular and bumpy with up to 5 mm of relief; some disturbed lamination consisting of alternating gray silt or sand and black clayey or organic material on the scale of 1 to 2 mm; scattered streaks of dark clayey material common in more massive upper half of unit; blebs and lenses of clean silt (endichnia?) about 5 mm wide are common; highly bioturbated throughout.....	36.8	235.2
13.	Siltstone, medium gray (N5); similar to units 14 and 15 but with thinner parting 1 cm thick; shows even plane lamination 1 to 3 mm thick, and discontinuous, uneven wavy lamination probably disturbed by horizontal burrowing; horizontal burrows 5 mm wide are visible on parting surfaces...	10.9	198.4
12.	Disturbed zone; high angle reverse fault; highly fractured and contorted siltstone beds and mudshale.....	5.0	187.5
11.	Claystone and mudstone; both are light olive gray (5Y5/2); some yellowish gray (5Y8/1) horizontal burrows; a few silt laminae less than 2 mm thick; a few siltstone beds 2 cm thick with uneven, wavy laminae. Unit 11 becomes siltier upward and siltstone beds become more abundant.....	24.7	182.5
10.	Mudshale (70 percent) with indistinct beds of siltstone 1 cm to 1.1 ft thick in a thinning-upward sequence. Mudshale is dark gray (N3); shows textural lamination.		

	Thickness (feet) Unit	Cum.
Siltstone is medium dark gray (N4); beds have irregular, wavy, uneven laminae of silt and clay; rare cross lamination in thinner beds; horizontal burrows are very common.....	17.4	157.8

NOTE: Units 1 through 9 comprise an overall thickening- and coarsening-upward sequence.

9. Siltstone (75 percent) in distinct beds up to 2.4 ft thick with interbeds of clay-shale or non-bedded siltstone (25 percent). Unit 9 shows an overall thinning-upward and is composed of two separate thinning-upward sequences. Lower thinning-upward sequence is about 20 ft thick and has a modal bed thickness of 0.6 ft. Upper thinning-upward sequence is about 11 ft thick and has a modal bed thickness of less than 0.2 ft. Distinct siltstone beds are medium gray (N5); evenly bedded, sharp basal contacts and sharp or slightly gradational upper contacts; top-truncated Bouma sequences and amalgamation of beds are common in lower 14 ft of unit; 90 percent of beds greater than 0.2 ft thick show Ta- Bouma sequences; Tc- Bouma sequences predominate in beds less than 0.2 ft thick; unit ABC proximity index (Walker, 1967) is 54 percent; a few shale clasts and sole markings, fine groove molds trend 264° at 14 ft above base of unit. Clayshale is dark gray (N3); shows textural lamination; very slightly silty; parting is 2 mm thick. Non-bedded siltstone is dark gray (N3); laminated, platy and less resistant than distinct siltstone beds; lamination consists of alternating layers of gray silt and black clay and organic matter; parting is 5 mm thick.....	31.2	140.4
8. Siltstone, non-bedded, platy; dark gray (N3); consists of alternating plane to wavy gray silt laminae and black laminae of clay and organic matter on the scale of 1 to 5 mm.		

		Thickness (feet) Unit	Cum.
	Some distinct beds of siltstone to very-fine-grained sandstone, 1 to 2 cm thick, expressed as ribs on outcrop; these layers pinch and swell and have wavy, disrupted lamination or cross-lamination. Horizontal burrows (silt filled endichnia) less than 5 mm wide are very common.....	3.3	109.2
7.	Sandstone, very-fine-grained, in four distinct beds, 0.4 to 1.4 ft thick; interbedded with platy, non-bedded siltstone as in unit 8. Sandstone beds show Ta- Bouma sequences; lowermost sandstone bed has a rippled top surface.....	4.7	105.9
6.	Siltstone, non-bedded, platy, as in unit 8..	5.0	101.2
5.	Siltstone in four distinct beds, 0.8 to 1.4 ft thick with little or no shale interbeds. Siltstone beds show Ta-, or Tb- Bouma sequences; shale clasts, and amalgamation of beds is common; one bed is discontinuous, beds are otherwise very even and persistent.....	4.4	96.2
4.	Siltstone (approximately 60 percent) with interbeds of clayshale (40 percent). Siltstone is dark gray (N3); bedding is indistinct; sedimentation units are difficult to identify; alternating laminae of gray silt and black organic-rich clay less than 1 to 3 mm thick; many laminae are wavy or disrupted; silt-filled endichnia are common. Clayshale is dark gray (N3), parting is 2 mm thick; very little disseminated silt.....	8.1	91.8
3.	Siltstone; non-bedded, platy. A resistant unit with sharp break in slope at base. Siltstone is grayish black (N2) and consists of alternating laminae of medium dark gray silt and black organic-rich clayey laminae 1 to 2 mm thick; many distinct siltstone layers less than 2 cm thick give outcrop a ribbed appearance where grouped; some siltstone layers pinch and swell and are laminated or cross-laminated.....	14.9	83.7

		Thickness (feet) Unit	Cum.
2.	Mudshale; consists of alternating laminae of black (N1) organic-rich clay (40 to 70 percent) and medium gray (N5) silt (30 to 60 percent). Silt laminae are 2 to 15 mm thick and give outcrop a ribbed appearance; become thicker and more numerous upward; predominantly even and continuous but pinch and swell layers and silt blebs are common; thicker silt layers are internally laminated; a few horizontal silt-filled burrows. Foerstia was found in middle of unit.....	14.8	68.8
1.	Clayshale to mudshale; coarsening upward; moderate brown (5YR4/4) in lower half of unit, grayish black (N2) to olive black (5Y2/1) in upper half of unit; more deeply weathered in lower half of unit where weathered color is pale yellowish brown (10YR6/2) to grayish orange (10YR7/4); in upper half of unit shale weathers medium light gray (N6) to medium dark gray (N4) with a blackish red (5R2/2) iron stain on parting surfaces. Shale shows textural lamination; silt laminae and streaks less than 1 mm to 3 mm thick are common and become thicker and more abundant upward; black shreds of organic matter are common; parting is 2 to 5 mm thick.....	54.0	54.0
	Total Chattanooga Shale (incomplete)...	575.3	

SECTION 34

U.S. Highway 25 Section

Complete section of gray silty shale unit of Chattanooga Shale exposed on east-facing slope of Poor Valley Ridge and in roadcuts along U.S. Highway 25E in Grainger County, Bean Station quadrangle, Tennessee (290300 meters East, 4025700 meters North, Universal Transverse Mercator Grid). Units 1 through 9 are described on east-facing slope of Poor Valley Ridge across U.S. Highway 25E and Annex Creek from "Mobil" Station. Units 10 through 12 are described at roadcuts along U.S. Highway 25E beginning apporximately 500 ft south of "Mobil" station. Section Measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, July 15 and 16, 1978, and its radioactibity profile measured with scintillometer by Paul D. Lundegard and Greg Hinterlong, November 9 and 10, 1978.

	Thickness (feet)	
	Unit	Cum.
Mississippian (incomplete):		
Basal siltstone member of Grainger Formation; not measured or described.		
Devonian (incomplete):		
Chattanooga Shale (incomplete):		
12. Clayshale, grayish black (N2) to black (N1), weathers dark gray (N3) to medium dark gray (N4); shows textural lamination; parting is 2 to 4 mm thick. A few thin siltstone beds, 0.1 to 0.3 ft thick in upper part of unit. Upper contact is gradational with Grainger Formation. Unit 12 was not described in detail; exposed across highway from small white house.....	119.0	453.3
11. Covered.....	150 ±	334.3
10. Claystone, light olive gray (5Y6/1), moderate reddish brown (10R4/6) varigations where weathered; silt-free; brownish black (5YR2/1) fragments of organic matter are common; sticky when wet; weathers to irregular chunks.....	16.0	184.3

NOTE: Units 1 through 9 are described on east-facing hillside of Poor Valley Ridge, across highway and Annex Creek from "Mobil" station. Unit 9 forms the crest of Poor Valley Ridge, and was correlated with the massive sandstone beds exposed along U.S. Highway 25 beneath unit 10 by Jacob's staff and Abney level.

	Thickness (feet) Unit	Cum.
9. Sandstone, very-fine-grained, light gray (N7) to yellowish gray (5Y8/1); irregular partings a few tenths of ft apart; a few distinct massive beds up to 2.6 ft thick; beds show disturbed irregular lamination, or wavy uneven laminae, streaks, and blebs or are structureless; lamination consists of alternating gray sand or silt layers and darker clayey layers. Lower 10 ft of unit 9 forms a vertical face and overhangs unit 8. Unit 9 forms crest of Poor Valley Ridge.....	53.0	168.3
8. Clayshale to mudshale with a few beds of siltstone and very-fine-grained sandstone, predominantly less than 0.1 ft thick. Shale is grayish black (N2); shows textural lamination; abundant silt laminae are medium dark gray and less than 1 mm to 1 cm thick; the abundance of silt laminae increases abruptly from about 10 percent to 60 percent at 5 ft above base of unit then gradually diminishes upward to less than 5 percent near top of unit. In this siltier zone silt laminae have a modal thickness of 4 to 5 mm; uneven pinch and swell layers and lenses predominate; a few silt laminae are internally plane laminated or cross-laminated; some horizontal burrows. A few distinct siltstone beds less than 0.1 ft thick occur between 2 and 5 ft above base of unit; beds pinch and swell; lamination consists of alternating gray and black, irregular, wavy laminae; distinct siltstone bed, 0.3 ft thick, at 1.7 ft above base of unit is very even and persistent; shows sharp base and slightly gradational top; Tab Bouma sequence; parting lineation trending 263° - 083°; immediately below this bed is a non-		

		Thickness (feet) Unit	Cum.
	resistant bed of medium light gray (N6) claystone, 0.5 ft thick.....	22.3	115.3
7.	Covered.....	21.0	93.0
6.	Siltstone, coarse-grained, to sandstone, very-fine-grained; poorly bedded; irregular partings 1 to 3 cm thick; wavy to discontinuous laminae of alternating gray silt or sand and black clayey material; a few distinct horizontal burrows.....	25.5	72.0
5.	Mudshale, grayish black (N2); shows textural lamination; laminae and streaks of silt up to 3 mm thick are abundant.....	4.5	46.5
4.	Interlaminated siltstone (60 percent) and mudshale (40 percent). Siltstone laminae, streaks, and blebs are medium gray (N5); 1 mm to 5 mm thick. Mudshale laminae are grayish black (N2); show textural lamination. Parting thickness ranges from 2 mm in shaly parts of unit, to 1 cm in silty parts.	5.0	42.0
3.	Claystone, olive gray (5Y4/1), weathers light olive gray (5Y6/1); non-resistant; shows some faint textural lamination; parting is subconchoidal, subparallel with bedding and 5 to 7 mm thick.....	8.0	37.0
2.	Mudshale with up to 5 percent siltstone beds less than 0.1 ft thick. Mudshale is black (N1); silt laminae, streaks, and blebs less than 3 mm thick are abundant and become more numerous upward; some textural lamination; parting is 2 to 5 mm thick; Foerstia found in lower 10 ft of unit. Siltstone is medium gray (N5); increases in abundance upward; somewhat irregular clayey laminae and cross laminae; a few hypichnial ridges; a few beds weather light brown (5YR5/6) and are probably sideritic. Upper 19 ft of unit forms nearly vertical face.....	22.0	29.0

	Thickness (feet) Unit	Cum.
1. Clayshale to claystone; both are medium dark gray (N4) to light olive gray (5Y6/1); slightly silty; minor yellowish gray (5Y8/1) weathering horizontal bioturbation; parting is 3 mm thick; clayshale shows textural lamination.....	7.0	7.0
Total Chattanooga Shale (incomplete)....	401.0	

SECTION 35

Rock Haven Section

Nearly complete section of gray silty shale unit of Chattanooga Shale exposed in roadcuts along old U.S. Highway 25E about 1.1 miles northwest of its intersection with U.S. Highway 11W in the Avondale quadrangle, Grainger County, Tennessee (285800 meters East, 4044200 meters North, Universal Transverse Mercator Grid). Section begins behind trailer home at community of Rock Haven, and continues southeast to where power lines cross over road. Section measured, described, and sampled using Jacob's staff, Abney level, and tape by Paul D. Lundegard, July 15, 1978, and its radioactivity profile measured using scintillometer by Paul D. Lundegard and Greg Hinterlong, November 9, 1978.

Mississippian (incomplete):

Basal siltstone member of Grainger Formation:

Not measured or described. Exposed in roadcut, 200 ft southeast of where utility lines cross over road.

Devonial (incomplete):

Chattanooga Shale (incomplete):

13.	Covered.....	85.0	371.8
12.	Clayshale, black (N1), weathers dark gray (N3); shows textural lamination; silt-free; parting is 2 to 3 mm thick; soft. Unit 12 is exposed beneath utility lines on the western flank of the ridge formed by the Grainger Formation.....	20.0	286.8

		Thickness (feet) Unit	Cum.
11.	Sandstone, very-fine-grained (50 percent), in beds 2 cm to 0.25 ft thick, with interbeds of clayshale (50 percent). Sandstone is pale yellowish brown (10YR6/2); structureless or with faint, discontinuous laminae. Clayshale is dark gray (N3), weathers medium dark gray (N4); shows textural lamination.....	5.0	266.8
10.	Covered. Scattered exposures of indistinctly bedded dark gray sandstone and very silty, dark gray shale.....	135.0	261.8
9.	Sandstone, fine-grained, in six fairly distinct beds; medium gray (N5) to medium dark gray (N4); structureless or with wavy, irregular lamination and randomly oriented black wisps of clayey material; some horizontal bioturbation.....	5.5	126.8
8.	Poorly exposed; sandy black (N1) shale, and platy, argillaceous sandstone with discontinuous, wavy laminae.....	3.9	121.3
7.	Sandstone, fine-grained, dark gray (N3); beds are 0.2 to 1.5 ft thick and generally indistinct and poorly defined; structureless or with irregular wavy and discontinuous laminae and streaks; sedimentation units are difficult to recognize. Interbeds are less resistant argillaceous sandstone and sandy shale with irregular parting 3 mm to 5 cm thick; wavy, discontinuous laminae and streaks of sand and clay; some distinct horizontal burrows. Fault with 2 ft of displacement at base of unit.....	38.9	117.4
6.	Sandstone, fine-grained, resistant, fractured, light gray (N6) to light brownish gray (5YR6/1), weathers grayish orange (10YR7/4); partings are 0.3 to 1.0 ft apart, uneven and subparallel to master bedding but commonly truncate each other; beds are structureless; sedimentation units are not identifiable.....	7.1	78.5

		Thickness (feet) Unit	Cum.
5.	Sandstone, very-fine-grained, dark gray (N3); indistinct bedding units are defined by the more persistent partings; the parting surfaces are very bumpy, largely because of abundant endichnial burrows less than 5 mm wide; major bedding units have disturbed, wavy lamination and irregular non-persistent partings 1 to 2 cm thick.....	8.4	71.4
4.	Mudshale with a few beds of siltstone 1 to 2 cm thick. Mudshale is black (N1); silt is dominantly as even, parallel laminae less than 1 mm to 5 mm thick; up to 20 megascopic laminae per centimeter; some silt-filled horizontal burrows; parting is platy and 2 to 5 mm thick; brittle. Siltstone is dark gray (N3); cross-laminated or showing wavy, discontinuous laminae. Unit 4 is described at vertical outcrop about 40 ft off road, and hidden by underbrush.....	26.5	63.0
3.	Covered.....	19.0	36.5

NOTE: Units 1 and 2 are described at outcrop behind trailer home.

2.	Claystone, light olive gray (5Y5/2) weathered; abundant yellowish gray (5Y8/1) to light olive gray (5Y6/1) weathering bioturbation; burrows are horizontal; individual burrows are less than 3 mm wide; approximately 60 percent bioturbation; small brown woody fragments are abundant.....	5.0	17.5
1.	Mudshale, black (N1), weathers dark gray (N3); plane and wavy silt laminae 1 to 2 mm thick and lensoid silt blebs up to 1 cm wide are common; parting is even and 3 to 5 mm thick; weathers to brittle plates; a few pinch and swell siltstone layers up to 2 cm thick show disturbed lamination. Foerstia was found in upper 4 ft of unit. Unit 1 forms subvertical face.....	12.5	12.5
	Total Chattanooga Shale (incomplete)...	371.8	

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