PETROGRAPHY AND STRATIGRAPHY OF THE STRATA OF THE LOWER — MIDDLE ORDOVICIAN CONTACT, CENTRAL PENNSYLVANIA

THESIS FOR THE DEGREE OF M. S.

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ABSTRACT

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Body of Abstract

This investigation concerns the petrology and stratigraphic relationships of a succession of intercalated limestone and dolomite beds at the contact between the Lower and Middle Ordovician in Central Pennsylvania. This sequence, herein referred to as the Transition Beds, is situated above the youngest typical Bellefonte Dolomite, uppermost formation of the Beekmantown Group, and below the oldest typical Loysburg Formation, lowermost formation of the rocks assigned to the Middle Ordovician. The Transition Beds range in thickness from 0 to over 400 feet. They occur at the stratigraphic interval occupied by the post-Beekmantown hiatus. The relationship of these beds to the disconformity is at the core of the problem of this study.

The Transition Beds consist almost entirely of micritic rocks. A few sparites can be found in the section but they are uncommon. The three most abundant rock types are: intramicrites, with the clasts composed of either torn-up algal mat or micrite; algal mat biomicrites, containing either continuous or disrupted algal mats, and micrites.

The petrographic analysis of the Transition Beds

indicates that this unit was deposited in a very shallow marine to intertidal to supratidal environment. The algal laminations are commonly found to have been disrupted by burrows, desiccation cracks and clasts torn loose by the turbulence of water.

The upper and lower contacts of the Transition Beds appear to be gradational with the adjacent units. The dolomite beds in the transition zone cannot be differentiated from those in the Bellefonte Dolomite. Likewise, the limestone beds in the transition zone and the Clover Limestone are very similar. Faunal diversity in the Transition Beds increases upward gradationally into the overlying Clover Limestone. The writer believes that the Transition Beds, where present, represent continuous deposition between the Lower Ordovician Bellefonte Dolomite and the Middle Ordovician Clover Limestone.

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INTRODUCTION

SCOPE

The purpose of this investigation was to determine the contact relationships between the Lower and Middle Ordovician strata of central Pennsylvania. At this stratigraphic interval an unconformity exists throughout the North American craton. Sloss (1963) has used this horizon as one of his sequence boundaries, the Sauk - Tippecanoe boundary. A widespread disconformity can be observed at this contact over most of the Appalachians (Butts, 1926, 1939; Butts and Moore, 1936; Cooper and Prouty, 1943; Cooper, 1944; Butts and Gildersleeve, 1948; Prouty, 1946, 1948; Wilson, 1948, 1949; Bridge, 1950, 1955; Munyan, 1951; Kellberg and Grant, 1956; and King and Ferguson, 1960). In many areas in Pennsylvania up to 400 feet of intercalated limestone and dolomite are present at this stratigraphic horizon.

The Beekmantown Group constitutes the entire Lower Ordovician in central Pennsylvania. In this region the Bellefonte formation is the uppermost unit of the Beekmantown Group. It is a dense, massive dolomite approximately 2,000 feet thick.

The Chazyan, which overlies the Beekmantown, is early Middle Ordovician in age and consists predominantly of limestone. The lowermost Chazyan formation is the Loysburg limestone. Kay (1944) divided the Loysburg Formation into two members, the Clover Limestone Member above and the "Tiger-striped" Member below. The Tiger-striped Member has been found to range in thickness from 0 to over 400 feet. In four measured and collected sections and in a number of other exposures this member was observed to consist of a series of intercalated limestone and dolomite beds of varying thicknesses. These beds were observed to have certain megascopic characteristics similar to the overlying Chazy and the underlying Beekmantown.

The relative age of the "Transition Beds" is in question. It is obvious from stratigraphic position, they must be either younger than the Beekmantown rocks, of the type Bellefonte, or older than the Chazy rocks, of the type Loysburg Formation (Clover Limestone).

AREA

The field work was conducted in the folded belt of central Pennsylvania. Figure 1 is a location map of the area. Investigation of the strata was confined to the area bordered by the Adirondack Axis on the east (coincident with Path Valley), the Pennsylvania Turnpike on the south (approximately 40° N. latitude), the Allegheny Front on the west, and approximately 41° N. latitude on the north.

The locations of the sections investigated are indicated on the map. In addition, localities referred to by other investigators which exhibit strata resembling the

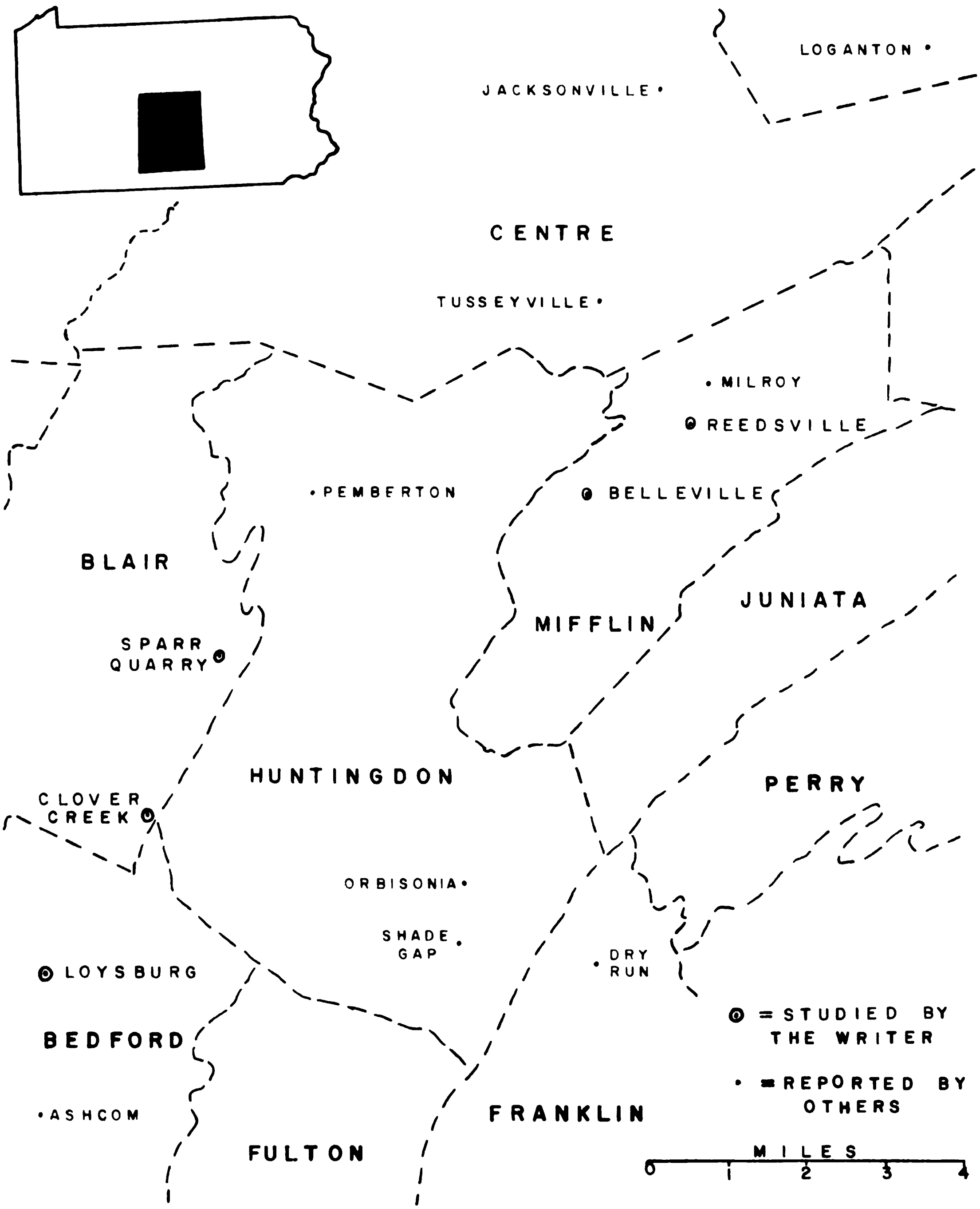


Figure 1.--Index map showing location of Transition Bed outcrops.

Transition Beds are also indicated (fig. 1).

This part of Pennsylvania is situated in the Ridge and Valley Province of the Appalachian Highlands. It is bordered by the Blue Ridge Province on the east and the Appalachian Plateau on the west. The Appalachian Valley is lower topographically than the surrounding regions. It is a belt ranging from thirty to one hundred miles in width extending from New York to Alabama. The rocks in this region are almost entirely sedimentary. They consist of thick units of sandstone, shale, limestone and dolomite. These beds have been extensively folded and faulted; this can be readily observed on a geologic map of the area. The rolling valleys are usually underlain by thick sequences of limestone and dolomite while the ridges are made up predominantly of sandstone units. Most of the folding and faulting is the result of compression during the final phases of the Appalachian orogeny.

PREVIOUS WORK

Discussion of the contact relationship which exists between the Beekmantown and the Chazy has been previously presented in the literature.

In 1936 Butts and Moore concluded that the problem exists because "there is no sharp lithologic boundary between the Bellefonte dolomite and the Carlim limestone, but the one passes into the other through a varying thickness of dolomite, including layers of pure-blue fossiliferous limestone of Carlim type . . ." The Carlim formation of Butts' includes the Transition Beds, in part or total, and the Clover and Hatter Formations of Figure 2. Butts (1939) again described the strata beneath the Carlim Limestone as "an alternation of layers of dolomite and scantily fossiliferous blue limestone . . ." He estimated a maximum thickness of 50 feet for these Transition Beds at an outcrop near Union Furnace, Huntington County, Pennsylvania.

G. Marshall Kay (1944) brought these units to light in his description of rock sequences in which interbedded limestones, laminated dolomites, and occasional intraformational conglomerates underlie the Clover Member of the Loysburg Formation. The lithologic similarity between these laminated dolomites and those of the Bellefonte formation led to the informal name "Transition Beds." Kay felt that the similar appearance of the dolomite units indicated that these transitional beds represent a conformable relationship between the subjacent upper Bellefonte Dolomite and superjacent Carlim Limestone. He described five localities at which these Transition Beds are present. Several of these are sections at which the interval under discussion is in excess of 200 feet thick.

Rones (1955), in his study of the Middle Ordovician of Central Pennsylvania, applied the name Milroy, a village in Centre County, to these transitional units. He estimated the maximum thickness of the Milroy to exceed 400 feet. Unfortunately, the type section is mostly covered and neither the upper nor lower contact is exposed.

In this paper the interval which has been previously referred to as either the Tiger-striped Member or the Milroy Member will be called the Transition Beds. This designation is preferred because of the transitional nature displayed by this unit.

FIELD PROCEDURES

Data gathered by C. E. Prouty (personal communication) during previous field investigations had established the fact that the lithologies of the formations immediately above and below the contact between the Lower and Middle Ordovician change laterally. Thus, the area under investigation was limited to that in which these units would be more readily identifiable from outcrop to outcrop. With these considerations in mind the area previously outlined was chosen.

The Transition Beds are absent from many outcrops containing rocks which range in age from Early to Middle Ordovician. The tectonic setting in which they were deposited has resulted in their discontinuous character.

The nature of the problem required that the sections to be studied consist of the Transition Beds and at least part of either the Loysburg Formation above and/or the Bellefonte formation beneath. No marker beds nor other structures were found within the transition zone which could be used to establish the stratigraphic position. Strata from formations above and below the transition zone were examined.

During the preliminary field investigation strata containing Transition Beds in contact with either the Loysburg Formation or the Belletonte formation were sought for later study. Of the localities observed in the five days of reconnaissant field work, five were chosen for detailed study. These five localities shall be referred to as the Reedsville, Belleville, Sparr Quarry, Clover Creek, and Loysburg, designated by the letters R, B, S, C, and L, respectively. Their locations are shown on the map on page 3. These sections were selected because of readily determinable contacts, greater thickness of outcrop, and greater continuity of outcrop than other sections containing the Transition Beds.

Every bed was measured to the nearest tenth of a foot in thickness. Samples were collected from each bed so as to show the characteristics of that bed. In cases in which a single bed varied in lithologic characteristics samples of each type were collected.

Specimens were chosen that consist of both a fresh surface and a weathered surface. The fresh surface was tested with a solution of 10% hydrochloric acid. Notations were made on the nature of the weathering of the strata and the primary and secondary structures that were observed. Every bed was carefully inspected in an attempt to collect as many fossils as possible.

REGIONAL STRATIGRAPHY

The strata investigated consist almost entirely of carbonate rocks with a few thin units of shale. A pronounced change is observed in the dominant lithology exhibited between the rocks of Early Ordovician age and those of Middle Ordovician age. The main constituent of the Lower Ordovician strata is dolomite, while that of the Middle Ordovician is limestone.

CANADIAN SERIES

Beekmantown Group

The Beekmantown Group represents all of the Lower Ordovician strata that accumulated in central Pennsylvania (fig. 2). The Beekmantown Group can be traced through western Vermont, New York, Pennsylvania, western Maryland, Virginia, and Tennessee. It is subdivided into four formations: Stonehenge Limestone, Nittany Dolomite, Axemann Limestone, and Bellefonte Dolomite.

Stonehenge Limestone - The oldest of these units is the Stonehenge Limestone. This formation ranges in thickness from 0 - 700 feet and is exposed in central and south-central Pennsylvania. This unit is not so widespread as the other three formations of the Beekmantown Group. In Centre County the Stonehenge formation is reported to be 630 feet thick.

The Stonehenge Limestone is composed chiefly of

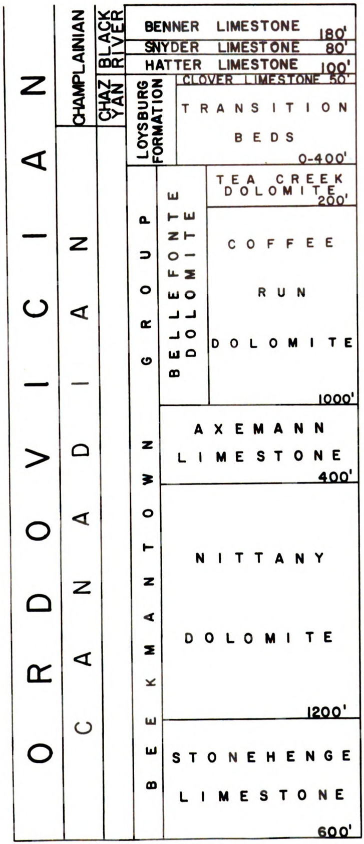


Figure 2.--Generalized stratigraphic column.

subequal portions of limestone and partially dolomitized limestone. The color of the limestone specimens is usually very dark gray, but ranges to medium gray.

Discoidal, rounded pebble or sand size intraclasts are very abundant in the Stonehenge Limestone, being either intrasparrudites (Folk, 1959) or intrasparites, respectively. Many of these assume the typical form of an "edgewise" conglomerate. Fossil fragments are present in minor quantity.

Nittany Dolomite - Above the Stonehenge formation is the Nittany Dolomite, with thicknesses of approximately 1,200 feet in Centre County and 1,000 feet in Blair County.

The Nittany Dolomite is composed almost entirely of dolomite beds, limestone units do occur within it but are very rare. The color ranges from very light to dark gray, medium gray being both the average and predominant color. Mottling, characterized by different shades of gray, is common.

The grain size ranges from aphanocrystalline to coarsely crystalline, averaging medium to finely crystalline. The Nittany Dolomite has been found to consist of beds in which oölite ghosts are readily visible. Intraclasts and fossil fragments are rare, obliteration by dolomitization being suggested as the cause (Folk, 1952).

Chert nodules are common in the Nittany Dolomite. The original oölitic texture of many of these is often preserved.

Axemann Limestone - The third formation of the Beekmantown Group is the Axemann Limestone. At its type section in Centre County, the Axemann is 158 feet thick, however its thickness ranges considerably.

The Axemann Limestone consists predominantly of dark gray slightly dolomitized limestone; massive homogeneous dolomites, constituting approximately 15% of the formation, are intercalated with the limestone. The limestone beds are usually dark gray in color, while the dolomite layers range from light to dark gray.

Limestone intraclasts are very common and usually form intrasparrudites and intrasparites in which the clasts are relatively flat-lying. Fossils are present in the Axemann strata. Silt and clay laminae are found in a great many of the beds. The layers in which the intraclasts are sparse or absent are usually micrite beds.

Chert nodules present in the Axemann are usually dark gray and show evidence of replacement.

Bellefonte Dolomite - The youngest formation of the Beekmantown Group is the Bellefonte Dolomite. At the town of Bellefonte in Centre County, it is 2,145 feet thick.

The formation was divided by Rones (1955) into a lower member, the Coffee Run Member, and an upper member, the Tea Creek Member. In the area covered by the Bellefonte Quadrangle and immediately adjacent to it a sandstone unit exists between the lower and upper members of the Bellefonte Dolomite. Where this unit is absent the division between the two dolomite members is based primarily on the degree of crystallinity and this differentiation is not always readily accomplished. The lower dolomite is approximately 1,000 feet thick; the sandstone unit has a maximum thickness of 12 feet; and the upper dolomite is about 200 feet thick.

Both the lower and upper dolomite units consist predominantly of massively bedded dolomites. The lower dolomite consists chiefly of light to medium gray, very finely to finely crystalline dolomite. A few beds which are medium to coarsely crystalline and some dark gray dolomites are present within the lower dolomite. The paucity of distinguishable allochems is believed due to their obliteration during dolomitization.

The Upper Bellefonte exhibits the finest crystallinity of all the Beekmantown dolomites, ranging from aphanocrystalline to finely crystalline and averaging very finely crystalline. The upper dolomite has a lower percentage of allochems than any other unit of the Beekmantown; fossils are extremely scarce. The color is the lightest of the Beekmantown units, ranging from light gray to medium dark gray.

CHAZYAN STAGE

The contact between the Lower and Middle Ordovician strata has been placed at the top of the Bellefonte formation, the highest formation of the Beekmantown Group.

Above this contact the rocks are of Chazyan age, early Middle Ordovician.

Loysburg Formation - The Loysburg Formation is divided into two units, the lower is the Transition Beds, previously referred to as either the Tiger-striped Member or the Milroy Member, and the higher is the Clover Member.

The Transition Beds are discussed in detail below.

The upper member of the Loysburg Formation is the Clover Member. This unit is a relatively pure limestone which is generally thin-bedded. Its thickness is about 60 feet in the area of this study. It is a dark fossiliferous limestone, containing a variety of different fossil groups. The Clover Limestone is generally a fine-grained micrite, and commonly is referred to as sublithographic.

MOHAWKIAN STAGE

Hatter Formation - Above the Loysburg Formation is the Hatter Formation, which is of Black River age. It is divided into three members, all composed of limestone.

Eyer Member - The Eyer Member is the lowest unit of the Hatter Formation. It is a dark, impure limestone with a texture ranging from a calcarenite to a calcirudite. It is fossiliferous and about 6 feet thick in the area studied.

Grazier Member - Above the Eyer is the Grazier Member. It is usually a dark, dense micritic limestone. This unit is approximately 30 feet thick and relatively barren of fossils.

Hostler Member - The Hostler Member is the uppermost unit of the Hatter Formation. It is a dark, impure limestone. The Hostler Member is thicker than the two units below it, ranging from 40 to 60 feet in thickness. Its most distinguishing characteristic is the fucoidal patterns displayed by many of its beds. This pattern stands out well on the weathered outcrops. The Hostler Member is known to have a large faunal assemblage.

S T R U C T U R E

The area investigated is part of the Appalachian mountain system. The northeast-southwest trending folded belt of this range is continuous from central Alabama to New Brunswick, a distance of fifteen hundred miles. This system is bounded on the southeast by the Cretaceous cover of the Coastal Plain in the southern and central sections and by the Atlantic Ocean in the northern section. The western boundary consists of the Allegheny and Cumberland Plateaus in the south and the Adirondack and Laurentian Mountains in the north.

The folded belt of the Appalachian system consists of three recesses; the central recess comprises the region referred to as the central portion of the Valley and Ridge Province. The apex of this recess is in central Pennsylvania, with its center of curvature in the city of Baltimore.

The area studied is typical of the central portion of the Valley and Ridge Province. This is an area described by Eardley (1962) as a region of flat-topped, parallel or subparallel ridges and valleys that are carved out of anticlines, synclines and thrust sheets. In central Pennsylvania the folds show considerable structural relief. They rise into the high anticlinorium of the Nittany Arch. The system of anticlines and synclines have a regional plunge to the southwest. This results in the famous zig-zag pattern observable on many of the topographic maps of this province. The folds are rarely symmetrical; the northwest limb usually has a steeper dip than the southeast limb. In many instances the beds are overturned.

The Transition Beds exhibit the same general attitude as the adjacent rock units, indicating that they deformed competently during the compression.

The best exposures are usually found along the flanks of the ridges. Continuous sections of strata are commonly exposed on the flanks of the folds dipping at angles between 30° and 50°.

T R A N S I T I O N   Z O N E

Portions of the formations subjacent and superjacent to the Transition Beds were also measured and collected. This was carried out to a greater degree at the lower contact, between the Bellefonte formation and the Transition Beds, than at the upper contact, the Transition Beds - Clover Limestone contact.

BELLEFONTE DOLOMITE

Tea Creek Member

The Tea Creek Member, upper member of the Bellefonte Dolomite, is an aphanitic, light brownish gray to medium gray dolomite which fractures conchoidally. The dense nature of the rock gives it a "cherty" appearance. This is a result of the very finely crystalline nature of the rock and not its mineralogy; only a minor quantity of chert was observed in the Tea Creek Member.

The strata contains layers of intraclastic limestone. The particles usually appear to have been torn from the underlying strata while it was still in a semiconsolidated state. This is indicated by the fact that the source material and clasts are in the same bed. In some instances it is possible to determine the probable strata from which the particles were derived. It was commonly observed that these intraformational breccia layers occurred superjacent to thinly laminated zones.

"Rosebud" (rosette) concretionary zones are present at various stratigraphic horizons. These zones are usually restricted to one bed, but are occasionally seen in adjacent beds. The "buds" vary in mineralogy, consisting of calcite, dolomite, or quartz. Almost all concretions examined are monomineralic. Likewise, each zone of rosebud concretions was also found to be essentially monomineralic. In a few cases the growth of the buds was observed to have pushed aside the fine laminations within the beds. This suggests that the rosebud concretions formed after deposition and before lithification of the enclosing strata. The buds ranged in size from incipient ones, a fraction of an inch in diameter, to large ones nearly a foot in diameter. Most of these concretions are longer parallel to the bedding, being somewhat ellipsoidal in shape. At highly weathered outcrops the rosebuds appear as irregular cavities, e.g., the Reedsville section.

The only fossils found in the Tea Creek Member comprise "reefy" layers. These are units in which the beds consist in part or total of a finely laminated structure. Occasionally these fine laminations can be traced along the bed to a site at which they mushroom into a "Cryptozoon" head. These are very similar to the space-linked hemispheroid stromatolites of Logan, Rezak, and Ginsburg (1964).

Another feature observed in the Tea Creek Member is a peculiar blotchy reddish-tan staining, the cause of which was not determined. The pattern of the stain is similar to those patterns developed in a fucoidal limestone. It is present in only a few units and apparently randomly distributed throughout the dolomite.

Stylolites are commonly observed in the beds. In addition, a surface of relief, up to half a foot in magnitude, is found between many adjacent beds. It is most noticeable at the Sparr Quarry locality where the beds dip steeply. This surface feature strongly resembles the karren surfaces that develop in karst areas.

TRANSITION BEDS

Stratigraphy - The Transitional Beds, the stratigraphic interval upon which this study was concentrated, do not occur as a continuous rock body throughout the area investigated. It is present only locally as lense-shaped masses. This form is suggested by the occurrence of sections varying in thickness from 0 to slightly more than 400 feet (Rones, 1955). The actual lense-shape could not be conclusively demonstrated because no outcrops were found which could be followed continuously for any considerable distance.

The Transition Beds, as the name implies, are lithologically transitional between the rocks above and below them. As has been previously mentioned the strata of Early Ordovician age are predominantly dolomite while those of Middle Ordovician age are limestone. The transition units exhibit a gradual change from the massive, thin-bedded (0.5 to 2 feet thick), aphanitic dolomites of the Tea Creek Member of the Bellefonte formation to the biomicrites of the Clover Member of the Loysburg Formation.

The aphanitic dolomite beds assigned herein to the Transition Beds are almost identical lithologically to the dolomite beds of the Tea Creek Member. The contact between the Transition Beds and the Bellefonte formation was placed directly beneath the first occurrence of a limestone bed. The limestone beds can be distinguished by color and weathering characteristics.

The Transition Beds have been referred to as the Tiger-striped Member or the Milroy Member of the Loysburg Formation as well as the Transition Beds proper. The first name is the result of units of very thin, ribbony, alternating bands of limestone and dolomite, which are usually less than an inch in thickness. Upon weathering this yields the "tiger-striped" pattern which prompted the name by Kay (1944) for the lower Loysburg. When weathered the dolomite bands stand out in relief against the less resistant limestone layers. The dolomite weathers to light brownish gray, the limestone to very light gray. The color distinction also contributes to the striped appearance. Units displaying the tiger-striped characteristics can be found occurring throughout the Transition Beds in thicknesses up to ten feet.

The majority of the strata in the Transition Beds of the Loysburg Formation are one to two feet thick, thin-bedded (Pettijohn, 1957). The lithology of the unit ranges from dolomite to limestone with shale constituting a very small percentage of the total thickness. The intercalation of the dolomite and limestone seems to be entirely random in distribution. The dolomite beds are fine-grained (finely crystalline) and are hard, dense rocks with a conchoidal fracture. The fresh rock is usually a light brownish gray to medium gray and has a "cherty" appearance similar to that described previously for the Bellefonte Dolomite. The dolomite beds weather to a light brownish gray to light gray. The limestone beds are medium gray to dark gray, commonly referred to as "blue," and weather to a very light gray.

The laminations, or reefy zones, and the intraformational breccias are present in the same manner and abundance as those in the Bellefonte formation. Several rosebud zones have been found in beds constituting part of the Transition Beds. Fossils, excluding the stromatolites, are commonly concentrated in layers in the Transition Beds. They are most abundant in the limstone beds.

Due to the lithologic similarities between the limestone beds of the upper portion of the Transition Beds and the Clover Limestone, I have placed the contact between these two formations directly beneath the first abundantly fossiliferous bed in which the megascopic forms present are abundant and varied and above which no thick layers of dolomite exist, i.e., greater than three feet in thickness. This faunal condition does not include ostracodes and trilobites which are well represented in the Transition Beds. I realize that this definition is subjective and will vary with the observer, however, due to the transitional nature of the units involved, I could not establish a more satisfactory operational definition.

Lithology - Polished slabs, approximately 1½ inches on each side, were used to investigate textural and structural features. It was found that fossils were more easily observed on the polished surfaces. A standard solution of 10% hydrochloric acid was used to etch the polished surfaces. The observations made have been combined with the field notes and are recorded in Appendix I, in addition to being incorporated into the general description of the Transition Beds.

Because the Sparr Quarry section was the most complete, containing no covered sections, it was studied most thoroughly. Thin-sections were made by a commercial firm. An insoluble residue analysis was performed which will be discussed later.

The dolomite layers range in color from a pinkish gray (5YR8/1) to a medium gray (N5) to a dark gray (N3) (Rock Color Chart, 1963). The most common color is in the medium gray range. The rocks rarely are restricted to a single color even within one hand specimen, more commonly a layered or mottled appearance is brought out by color variations. The dolomite beds usually weather to a color commonly referred to as buff, which closely resembles a cross between yellowish gray (5Y8/1) and very pale orange (10YR8/2).

The dolomite beds are hard, dense, and commonly break with a pronounced conchoidal fracture. The dense nature of the rock also gives it a "cherty" appearance.

The dolomite layers in the Transition Beds are typically massive and thin-bedded, usually on the order of one to two feet in thickness. In many of the dolomite beds fine laminations are readily distinguishable on the weathered surfaces. This characteristic is produced by very thin zones of more resistant layers within the dolomite beds. On a polished section the origin of the laminations is revealed as the product of blue-green algae. In the field strata containing these bands can in many places be traced until they are seen to expand into the head of "Cryptozoon-like" structures.

After examining a representative suite of the samples it becomes apparent that the blue-green algal mat is the dominant sediment type in the section. The majority of the beds contain at least some indication of the ubiquitous presence of the algal mats. The algae, all of the blue-green variety, is present in a number of forms. The presence of the algal structures can, in most cases, be recognized even after extensive dolomitization.

One sediment type frequently encountered is the (dolomitized) algal mat biomicrite (Folk, 1959, 1962). In this case the algae occur in fairly continuous layers which are subparallel to one another and to the bedding. The individual layers typically exhibit a crenulated form. The continuity of the mat is interrupted occasionally by burrows, eruption features caused by escaping gas, desiccation cracks, clasts torn loose by water turbulence, and other such phenomena whose agent is as yet unrecognized.

The algal mats in many places occur in a form which the author has chosen to refer to as a (dolomitized) disturbed algal mat biomicrite. This genetic, rather than descriptive terminology, calls attention to a sediment type very similar to the one discussed immediately above. The disturbed algal mat biomicrite is a torn-up algal mat. The clasts present in this sediment type are almost entirely composed of pieces of algal mat and some of the associated micrite layers. Storm generated waves is one possible mechanism for producing a disturbed algal mat biomicrite. The algal mat intraclasts along with the adjacent layers of complete or only partially torn-up algal mat suggests that the intraclasts were derived from the immediate vicinity and have not suffered much from mechanical attack. In many instances a discontinuous string of pebble size intraclasts can be seen as the remnants of a once continuous algal layer. The general lack of sorting and the subangular shape of the intraclasts support this interpretation. All gradations between the continuous algal mat biomicrite and the disturbed algal mat biomicrite can be found in the strata investigated. This is the reason for the reference to this as a disturbed biomicrite rather than calling it an intramicrite, the descriptive category into which these rocks would be classed.

In some beds layers of algal mat occur in a dominantly micritic or intraclastic rock. This lithology is referred to as either a (dolomitized) algal mat-bearing micrite (or intramicrite), if the algal layers make up less than 10% of the rock, or as a (dolomitized) sparse algal mat biomicrite, if the algal layers constitute 10 - 50% of the rock.

Another sediment type in which the presence of blue-green algae is recognized is in (dolomitized) intramicrites. Intraclasts of algal mat composition are often common and interspersed with intraclasts of micrite. The rock is classified as an intraclastic rock when the algal mat intraclasts do not appear to have come from the immediately adjacent or subjacent strata. The larger intraclasts, both those composed of torn-up algal mat and of torn-up micrite, have in many examples been found to fall into the fine calcirudite class, 1 to 4 mm. These clasts are almost always surrounded by a micrite matrix.

Finer sized intraclasts, ranging from coarse calcilutite (0.031 mm - 0.062 mm) to fine calcarenite (0.125

mm - 0.25 mm), occur as bands intercalated with either algal mats, micrite layers, or zones of coarser intraclasts. The finer intraclasts occasionally form isolated pockets in the algal mats or on top of micrite layers. These bands are usually much better sorted than the coarser intraclasts and rarely if ever found intermixed with the coarser material. The bands, in some instances, exhibit graded bedding. The finer intraclasts are commonly cemented by spar. In a few cases, channels, some as small as 1 cm across, have been cut in micrite layers and filled with very fine arenite sized clasts. In one specimen the channel fill was observed to demonstrate graded bedding. In only one or two instances could clasts be identified as extraclasts (Wolf, 1965). Oölites have been found but are extremely rare.

It is apparent that the various sediment types found in the Transition Beds occur adjacent to one another and frequently two or more occur within the same bed. In fact it is the rarer occasion when a bed is composed of a single lithology and not a composite of the types mentioned above.

Burrows are common in many of the transition units. However, it is often difficult to determine whether the "mottled" appearance of the extensively dolomitized units is due to burrowing or is the result of preferential dolomitization. Frequently the weathered rock surfaces exhibit a pattern which has been commonly referred to as "fucoidal."

It is the author's opinion that in most instances this structure is the result of burrowing. However, in instances in which the cause was not determinable the term fucoidal was used to describe the rock.

The individual dolomite rhombs are almost entirely finely crystalline (0.0156 mm - 0.0625 mm) in size with extremes ranking from very finely crystalline (0.0039 mm - 0.0156 mm) to medium crystalline (0.0625 mm - 0.25 mm). The size range of the individual crystals is usually small and there is a homogeneous complexion to the rock. There are single specimens in which dolomite rhombs of two different sizes exist adjacent to one another. This texture is believed to be the result of dolomite replacing former "structures," however, only the outlines of the ghosts could be determined and not their original characteristics. Organic matter was frequently observed associated with many of the ghosts. This has led to the belief that in such cases these ghosts are the replaced remains of fossil material.

Many of the dolomite rhombs are very well developed and can easily be recognized with the use of a petrographic microscope. In the strata which has been only partially dolomitized, the dolomite rhombs can be seen to be "floating" in a micrite matrix.

The limestone units in the Transition Beds are quite similar to the dolomite units in overall appearance. They are usually a little darker gray than the dolomite beds, however, they too range widely in color. Where they are weathered the limestone beds are somewhat easier to distinguish. Their surface is very light gray (N8), referred to in the field as "creamy white."

The limestone units are aphanitic and break with a conchoidal fracture similar in character to, but less pronounced than, that of the dolomite beds. The limestone layers are almost exclusively micritic. They universally exhibit evidence of dolomitization. This is present in the form of scattered dolomite rhombs or strips in the micrite. The dolomite rhombs have been found to occur as isolated crystals in micrite, irregular, wavy layers of rhombs alternating with layers of micrite, or as clusters of dolomite crystals surrounded by micrite.

The limestone beds contain the only abundant recognizable fossil remains found in the Transition Beds with the exception of the stromatolites. The fossils are tightly bound within the rock which enclosed them and therefore do not readily weather out of the rock. Concentrations of fossils were restricted to narrow bands within fossil-bearing beds. In a few specimens from limestone beds there are fecal pellets. Their occurrence was usually restricted to those beds which contain fossil fragments.

<u>Paleontology</u> - The Transition Beds contain little faunal diversity. However, the diversity of the phyla present and the genera within the phylum and the abundance

of the fossil fragments increase with units of higher stratigraphic position.

The thinly-laminated stromatolite zones with the "Cryptozoon heads" extend throughout the transition zone. None of these were larger than one and a half feet in the lateral direction and a foot in the vertical. The structures are of the space-linked hemispheroid form (Logan, Rezak, and Ginsburg, 1964); that is, the "space between the structures is greater than the diameter of the structures."

The algal mats, the thinly-laminated structures, act as sediment binders. These organosedimentary features "characteristically develop in continuous mats and algal-bound sediments from the marine, intertidal mud-flat environment, mainly in the protected locations of re-entrant bays and behind barrier islands and ridges where wave action is usually slight" (Logan, Rezak, and Ginsburg, 1964). They have also found that as many as twenty-eight different genera of algae can live in the community that builds these stromatolitic structures and that the form is usually due to the interaction of the algal mat, detrital sediment, and the physical environmental factors.

Smooth ostracode carapaces, highly fragmental, were very abundant in the limestone units. The general outline of the valves and the apparent lack of ornamentation suggests that the ostracodes possibly belong to the Leperditiidae family. The ostracodes show no apparent change in form throughout their vertical distribution within the Transition Beds.

Trilobites occur within the Transition Beds. Their first appearance is higher in the section than that of the ostracodes. Trilobite fragments are abundant at the Belleville locality and were collected from this site. The mode of preservation did not permit any identification of these pieces. The adhesion between the micrite and the shell was such that the micrite could not be removed from the shell with a Vibra-tool even after treatment with dilute acid.

Abundant pelmatazoon fragments occur in the limestone beds directly beneath the top of the Transition Beds. Other fragments were identified in slides from the limestone beds slightly less than thirty feet below the top of the Transition Beds.

Gastropods resembling Maclurites were found just beneath the Transition Beds - Clover Limestone contact at the Sparr Quarry locality.

Brachiopod and bryozoan fragments are uncommon in the interval assigned to the transition zone.

Residue analysis - An insoluble residue analysis was performed on the samples from the Sparr Quarry section. The quantitative results of this investigation can be found in Appendix II.

The coarse-grained insolubles were studied under a binocular microscope after decanting the clay portion.

The clay portion of the insoluble residues were separated from the coarse and then discarded. The treatment of rocks with hydrochloric acid destroys many clay minerals, so that X-ray analysis of this portion of the insoluble residue would have been of little value.

The composition of the coarse insoluble residue of the Transition Beds was uniform throughout and consisted of quartz and chert. No systematic variation of the relative abundance between these two components was noted. X-ray diffraction recordings were made of several of the insoluble residues and the patterns showed that feldspars, in addition to quartz and chert, were present in all the samples X-rayed.

The insoluble residue analysis was performed with the hope that some significant variation of the percentages by weight of insoluble residue in the samples would be found and related to the stratigraphic position. Therefore, the data were experimentally plotted in various ways to see if any trend would be found. The insoluble residue percentages by weight were first plotted bed by bed as a histogram; this resulted in a very irregular pattern. Since the writer was attempting to find a trend he took the values of the insoluble residue percentages at five foot intervals and plotted these values; again the result was an irregular plot. The final attempt to find a pattern was to take a moving average of the values both five feet above and five feet beneath; again no general trend was discernible. All three plots can be seen in the pocket (plates 1, 2, and 3).

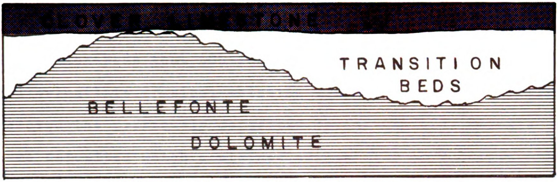
The relative abundance of insoluble material in the limestone beds compared with those in the dolomite beds was investigated also. This too showed no significant results.

SUMMARY AND CONCLUSIONS

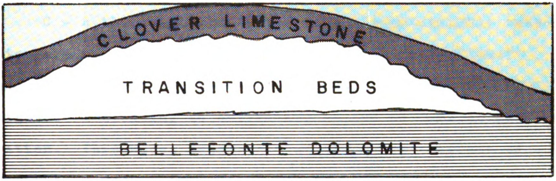
As stated above this investigation was initiated to determine the stratigraphic relationships between the Transition Beds and the Lower and Middle Ordovician strata. A disconformity has been recognized between the Lower and Middle Ordovician at many localities in the Appalachians. The problem as it exists in Central Pennsylvania can be depicted as shown in Figure 3. There are three interpretations possible:

A - Following the deposition of the Beekmantown Group the area under investigation may have been uplifted and eroded. The interval during which the erosion of this carbonate surface took place would need to have been of sufficient magnitude to permit up to 400 feet of relief to develop. After this erosional surface had formed the area was submerged and the Transition Beds were deposited. This was followed by deposition of the Loysburg Formation as a continuous accumulation of carbonate sediments. In this model a disconformity exists between the Beekmantown Group, top of the Bellefonte formation, and the bottom of the Transition Beds.

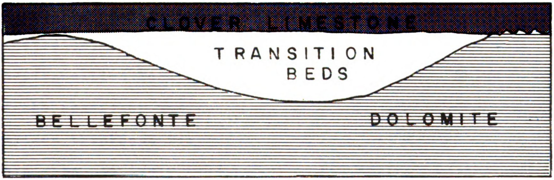
B - Another possible interpretation of this stratigraphic interval postulates continuous accumulation of sediment from the Beekmantown Group through the top of the Transition Beds. After accumulation of the Transition Beds the area was then exposed to subaerial erosion. So



A - Uplift and erosion of Bellefonte Dolomite followed by continuous deposition of the Transition Beds and the Clover Limestone.



B - Continuous deposition from the Bellefonte Dolomite **through** the Transition Beds followed by uplift and erosion and then deposition of the Clover Limestone.



C - Continuous deposition throughout the entire depositional sequence. Possibly erosion on highs shown at right.

Figure 3.--Schematic representation of alternative explanations for the sedimentological history of the Bellefonte - Clover sequence.

that in this scheme it is upon the upper surface of the Transition Beds that 400 feet of relief was developed. Following this erosion, which in many instances completely removed the previously deposited Transition Beds, strata were deposited which contained essentially no dolomite units. In this second instance, a disconformity should be present between the top of the Transition Beds and the base of the Loysburg Formation.

C - A third interpretation of the stratigraphic relationship envisions a continuous accumulation in "lows" and no deposition on pene-contemporaneous "highs." The highs corresponding to anticlines in the process of formation. This model suggests that the marine surface of deposition was an irregular surface of topographic highs and lows. This tectonic framework would account for the stratigraphic relationships observed and does not necessitate the existence of an unconformity, a buried surface of erosion, between any of the units. The areas in which the Transition Beds are absent would represent the highs of the sea floor and those in which the beds attain their maximum thickness would represent the loci of the lows. This does not imply that these two parts always remained in the same geographic position and did not migrate. This is a distinct possibility, however, and no definitive statements can be made concerning this premise without further investigation. The area of thick accumulation of Transition Beds would then represent continuous accumulation without erosion, while those section from which these units are absent could either be localities at which subaerial erosion or even submarine erosion took place, or they might represent zones at which no deposition and no erosion occurred, i.e., zones of by-pass.

This model of deposition controlled by an active basement during the early Paleozoic was borrowed from a paper by B. N. Cooper (1964). He concerns himself in this paper in part with the same stratigraphic interval in the southern Appalachians as considered in this study.

The writer favors the last of these three possible interpretations because of the following reasons:

Nowhere did the author observe any physical evidence for an unconformity in the strata which was studied in the field. A disconformity along which up to 400 feet of erosion has occurred might be expected to leave some physical evidence, either in the form of a surface of erosion or resulting deposits. Inability to observe a surface of truncation is not regarded as a serious objection because all sections observed were steeply dipping, in the order of 40°, and therefore no individual surfaces could be traced for any considerable distance. However, it is believed that a basal conglomerate would have been present had the erosion taken place.

The change from strata which are entirely dolomite, Bellefonte formation, to those which are entirely limestone, Clover Formation, is a gradual one and does not take place abruptly. No horizons can be distinguished at which a sharp lithologic contrast can be demonstrated. The change takes place with the dolomite beds of the Bellefonte formation grading into intercalated dolomite and limestone beds. The dolomite layers are more abundant than the limestone layers near the base of the Transition Beds and the limestone increases in proportion upwards. This continues until the strata become composed entirely of limestone units in the Clover Formation.

The lithology of the individual beds also gives very little evidence for any major break in deposition. The dolomite units of the Transition Beds cannot be differentiated from those of the Bellefonte Dolomite by petrographic means or by their insoluble residue content. The limestone layers of the Transition Beds are similar to those of the Loysburg Formation.

As discussed previously the paleontology of the transition zone changes from one in which there is very little faunal diversity at the base to one in which a greater diversity of phyla and a greater number of genera within the various phyla increase in the younger beds. This appears to grade into the faunal distribution as found in the Clover Limestone.

Attempts were made to find a means of correlating between the four measured and collected sections. The lithology, paleontology, and any associated features that were incorporated with the rock were used to try and tie sections together. However, the attempt was unsuccessful.

This lack of correlation can be understood when considered in light of the paleogeographic interpretations herein suggested for the area. The variations between sections suggest the possibility that these units were not deposited as continuous sheet-like layers as the early Paleozoic strata of the Appalachians are often envisioned. There is a distinct possibility that the Transition Beds were deposited in semi-isolated basins of deposition which were separated from each other by ridges, either submreged or emerged.

Mentioned above is the common association of thinly laminated zones with the limestone intraclasts. Logan, Rezak, and Ginsburg (1964) have described a similar occurrence from the present. They have found that "the sediments are usually wet and soft in the littoral but may grade into a blocky indurated calcarenite in the supralittoral; laminated flat-pebble conglomerate and breccias are common in this zone." The identification of desiccation cracked algal mat layers strongly suggests a supratidal or intertidal environment of deposition for some of the Transition Beds. Taking this into consideration it appears that the Transition Beds were deposited in basins which must have ranged from very shallow water to supratidal.

For the above reasons, the writer favors an interpretation of the Transition Beds which holds them as representing continuous deposition between the Beekmantown Group below and the Loysburg Formation above.

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APPENDIX I

MEASURED SECTIONS

The five localities studied--Reedsville, Sparr Quarry, Belleville, Loysburg, and Clover Creek--were designated by the letters R, S, B, L, and C, respectively. The specimens from these localities were numbered in a consecutive order starting with number 1 at the beginning of each outcrop. When more than one sample was collected from a single bed the different samples were further designated by a small subscript letter following the number, so that the second sample from the 38th bed studied at Sparr Quarry would be labeled $S\text{-}38_B$.

The terminology used to describe the strata studied in this investigation is a slightly modified version of Folk (1959, 1962).

Sparr Quarry Section

Williamsburg Quadrangle, Pennsylvania (7.5 minute, 1963)

Latitude 40°26'38" N.
Longitude 78°10'48" W.

From the town of Williamsburg this locality can be reached by proceeding east on Third Street until the street ends at a hillside and at this point turning to the right along the stone wall. The road divides a short ways from this point and the left-hand fork uphill should be taken. Approximately one-quarter of a mile out of town another left-hand turn is taken, again uphill. This road is taken until a dirt road entering from the right is encountered just before Clover Creek is reached. This dirt road is followed, the quarry is a short distance along this road. The second site of excavation is the locality at which this section was measured. This quarry was not in operation at the time of this study, summer of 1963, and had not been for quite a few years. The strata are striking N. 17° E. and dipping 40° to the southeast.

The lowest rock unit exposed in the quarry is the Bellefonte Dolomite and the highest in this section of the quarry is the Hatter Formation and possibly some of the unit directly above it. There are no covered sections and the exposure is good. The quarry was worked perpendicular to strike, leaving a good continuous outcrop. Approximately 170 feet of strata belonging to the Transition Beds crop out in the quarry and both the upper and the lower contacts are exposed.

Description	Thickness in feet	Feet above base
Loysburg Formation: 197.9' measured.		
Clover Member: 27.4' measured.		
S-62: Intramicrite, dolomitized in patches; minor amount of stromatolitic laminations; medium light gray to light brown.	2.5	289.7
S-61: Intramicrite, partially dolomitized; clasts of at least three limestone lithologies, some of the clasts are well rounded; medium gray to light tan.	2.5	287.2
S-60: Medium crystalline dolomite; dolomite rhombs well developed; wavy silty laminations; light gray to light olive gray.	2.5	284.7
S-59: Dolomitized disturbed algal mat biomicrite; minor amount of hematite in cubes; medium gray to light olive gray.	2.5	282.2
S-58: Algal mat biomicrite intercalated with micrite and intramicrudite, contains ostracodes, trilobites and brachiopods; medium gray.	6.1	276.1
S-57: Grades from a dolomitized biomicrite up into an intramicrudite; medium gray to light olive gray.	2.5	273.6
S-56: Sparse intramicrudite, contains minor amount of algal layers; partially dolomitized, laminated and intraclastic zone prominent near top of unit; dark gray.	2.5	271.1
S-55: Sparse intramicrite; partially dolomitized, rhombs well developed, contains hematite along fractures; medium gray.	2.6	268.5
S-54: Fossiliferous intramicrudite and intrasparite; contains ostracodes,	3.7	264.8

Description	Thickness in feet	Feet above base
trilobites, echinoderm fragments, algal layers, Maclurites (?); dark gray; fucoidal appearance on weathered surface.		
Transition Beds: 170.5' measured.		
S-53: Finely crystalline intraclastic dolomite; alternating bands of intramicrite and micrite up to 0.2' thick; contains 0.1 mm blobs of spar also a great abundance of hematite altering to limonite; light olive gray.	1.3	263.5
S-52: Dolomitized fossiliferous algal mat intramicrudite and fossiliferous micrite; "cloud-like" mottled pattern due to dolomitization; dark gray.	3.6	259.9
S-51: Dolomitized disturbed algal mat intramicrite with bands of pure micrite; appears to be a solid stromatolitic mass; brownish gray.	4.1	255.8
S-50: Fossiliferous intramicrudite; contains ostracodes, trilobites, and echinoderms (?); medium gray; fucoidal appearance on weathered surface.	3.9	251.9
S-49: Fossiliferous biomicrite and fossiliferous intramicrudite; dolomitized in patches; contains ostracodes and trilobites; "cloud-like" mottled pattern due to dolomitization; medium gray to light olive gray.	2.7	249.2
S-48: Dolomitized fossiliferous pelmicrite; pellets exhibit cross bedding; minor amount algal mat laminations; top of unit shows shaly parting; contains abundant pyrite; dark gray.	4.2	245.0
S-47: Dolomitized calcareous shale; dark gray; very distinct in field.	0.6	244.4
S-46: Dolomitized fossiliferous	2.0	242.4

Description	Thickness in feet	Feet above base
pelmicrite and intramicrudite; contains algal mat laminations; edgewise conglomerate near top of unit; medium gray.		
S-45: Dolomitized algal mat biomicrite; algal layers selectively enriched in hematite; light gray; laminations stand out well on weathered surface.	6.2	236.2
S-44: Dolomitized pellet-bearing biomicrite; mottled appearance due to dolomitization; spar occurs in layers; contains abundant pyrite and hematite; medium gray.	2.7	233.5
S-43: Fossiliferous and algal mat-bearing intramicrudite; contains ostracodes and trilobites; some of the clasts are torn-up algal mat; a few of the clasts show a concentration of hematite; medium gray to brownish gray.	6.6	226.9
S-42: Dolomitized burrowed dismicrite; rich in organic matter and hematite; medium gray.	5.2	221.7
S-41: Dolomitized algal mat biomicrite; dolomitized in strips; algal layers 1 to 2 mm thick; medium gray.	8.2	213.5
S-40: Finely crystalline dolomite; no visible structure; rich in organic matter and pyrite; medium gray.	8.3	205.2
S-39: Dolomitized disturbed algal mat biomicrite; dolomitized in bands; prominent stromatolitic appearance to the unit; laminated bands 0.4 - 1.5' thick; edgewise conglomerate near top; dark gray.	8.7	196.5
S-38: Finely crystalline dolomite; concentrations of well developed dolomite crystals; rich in pyrite; dark gray.	13.3	183.2
S-37: Dolomitized micrite intercalated with pelsparite; lower portion	7.6	175.6

Description	Thickness in feet	Feet above base
of unit has rosebud concretion zone; middle portion dolomite with calcite in bands; top of unit is a finely crystalline dolomite; dark gray.		
S-36: Dolomitized disturbed algal mat biomicrite; burrowed; medium gray.	8.2	167.4
S-35: Dolomitized intraclast-bearing dismicrite; abundant hematite in veins associated with larger crystals of dolomite; medium gray.		
S-34: Dolomitized micrite; completely dolomitized; rich in disseminated hematite; brownish gray; shaly parting on weathering.	5.8	159.7
S-33: Dolomitized intraclast-bearing algal mat biomicrite; algal mats abundant along base of unit; intramicrite prominent at top; magnetite concentrations along joints; medium gray.	2.4	157.3
S-32: Micrite; rich in organic matter, hematite, and some clear quartz grains; unit is shaly near its base, laminations increase upwards, topped by thin striped zone; medium dark gray.	0.8	156.5
S-31: Dolomitized algal mat-bearing micrite, some pelsparite zones; sorting of two different sized dolomite crystals yield distinguishable layers; poorly defined tiger-striped appearance; medium gray.	10.2	146.3
S-30: Dolomitized pelletiferous micrite; medium to medium dark gray.	3.3	143.0
S-29: Dolomitized algal mat biomicrite; finely laminated; abundant stylolites; medium gray.	10.0	133.0
S-28: Pellet-bearing ostracode biomicrite; dolomitized in strips;	6.7	126.3

Description	Thickness in feet	Feet above base
prominent tiger-striped unit, forms overhanging ledge in quarry; medium gray.		
S-27: Shaly dolomitized algal mat biomicrite; rich in organic matter; dark gray.	0.2	126.1
S-26: Dolomitized pelletiferous and algal mat-bearing intramicrudite; rich in hematite; medium dark gray.	2.6	123.5
S-25: Finely crystalline biogenic dolomite; appears to be replaced algal mat with some intraclastic zones; contains a sparse concentration of rosebuds in lower 2' of unit, rosebuds are anhydrite; light brownish gray.	6.6	116.9
S-24: Dolomitized algal mat biomicrite; contains a coarse intramicrite in middle of bed; abundant pyrite crystals; finely laminated lower portion of unit; medium to medium dark gray.	3.9	113.0
S-23: Dolomitized intramicrudite and dolomitized algal mat biomicrite; some dolomitized micrite zones; well developed rosebud concretion zone about 5' from base of unit, rosebuds of calcite; stromatolitic "head" from lower part of unit projects along minor break into middle part of unit, head approximately 1.5' long and 0.5' high; medium dark gray.	7.1	105.9
S-22: Varies from dolomitized algal mat biomicrite at base to dolomitized micrite to micrite at top; medium dark to medium light gray.	8.0	97.9
S-21: Dolomitized sparse algal mat biomicrite; medium gray.	0.6	97.3
S-20: Algal mat biomicrite; partially dolomitized in bands, mottled; forms tiger-striped unit; medium gray.	3.0	94.3

Description	Thickness in feet	Feet above base
Bellefonte Dolomite: 94.3' measured.		
S-19: Dolomitized micrite; dolomite rhombs of medium crystal size (0.0625 - 0.25 mm); randomly distributed pores have pyrite in centers; medium to medium dark gray.	4.0	90.3
S-18: Dolomitized sparse algal mat biomicrite; structures somewhat obscured by mottling; medium gray.	0.8	89.5
S-17: Dolomitized intramicrudite and algal mat biomicrite; grades up into more limy portion; edgewise conglomerate just beneath top of unit; medium gray.	6.3	83.2
S-16: Dolomitized algal mat intramicrudite; rich in hematite and pyrite; red staining prominent; medium light gray.	5.0	78.2
S-15: Dolomitized algal mat intramicrudite; laminated zone grades upward into intraclastic zone; red staining prominent; medium light gray.	4.8	73.4
S-14: Dolomitized pelletiferous algla mat biomicrite; dolomite rhombs in bands; prominent red staining; medium light gray.	2.6	70.8
S-13: Dolomitized fossiliferous micrite; contains a small percentage of sponge spicules; has graded cross-bedded allochems; top of unit has a prominent rosebud zone, rosebuds filled with sparry calcite around the outside and with quartz crystals filling the centers; randomly distributed oxidized pyrite crystals; brownish gray to pale yellowish brown; "stylolite-like" relief along top of bed.	3.4	67.4
S-12: Dolomitized pelmicrite; streaks of hematite staining; medium gray; stylolitic relief both top and bottom of bed.	3.4	64.0

Description	Thickness in feet	Feet above base
S-11: Dolomitized pelmicrite; mottled; calcite rosebud zone, buds up to 0.8' long; prominent silty zones; medium dark gray.	3.9	60.1
S-10: Dolomitized pelmicrite; algal mat layers; two prominent rosebud zones; medium dark gray.	7.5	52.6
S-9: Finely crystalline dolomite; mottled; weathered surface shows algal (?) laminations; medium gray.	3.7	48.9
S-8: Finely crystalline biogenic dolomite; mottled; stromatolitic laminations and crowns stand out on weathered surface; calcite rosebud concretionary zone approximately 3' above base; stylolites well developed; medium gray; relief along beds; top surface is stylolithic.	10.7	38.2
S-7: Finely crystalline biogenic dolomite; mottled; algal mat laminations stand out on weathered surfaces, rich in hematite crystals after pyrite; dolomite rhombs vary considerably in size; light brownish gray.	9.5	28.7
S-6: Finely crystalline biogenic dolomite; calcite rosebud concretionary zone about 2.5' above base of unit; medium dark gray to brownish gray.	5.9	22.8
S-5: Finely crystalline biogenic dolomite; algal laminations stand out on weathered surfaces; medium dark gray; relief up to 0.5' along top of bed.	4.7	18.1
S-4: Finely crystalline biogenic dolomite; small calcite rosebud concretions; medium gray.	3.1	15.0
S-3: Finely crystalline biogenic dolomite; light brownish gray.	6.0	9.0
S-2: Dolomitized algal mat	6.0	3.0

Description	Thickness in feet	Feet above base
biomicrite and intramicrudite; medium gray.		
S-1: Finely crystalline biogenic dolomite; algal laminations; medium gray.	3.0	0.0

Reedsville Section

Lewistown Quadrangle, Pennsylvania

Latitude 40°40'34" N.
Longitude 77°35'70" W.

This section is situated along Route 322 between Reedsville and Milroy, approximately three-quarters of a mile northwest of Reedsville. The average strike of the outcrop is about N. 48° E. and dips 43° to the southeast.

The strata crop out in three sections: the first consisting entirely of the Tea Creek Dolomite, the second of both Tea Creek Dolomite and Transition Beds, and the third of Transition Beds and the Clover Limestone and younger formations. A large covered area, 120 feet stratigraphically, exists between the second and third sections, within the Transition Beds.

The part of the outcrop which was measured and collected, consisting of a portion of the Bellefonte Dolomite up to the Eyer Member of the Hatter Formation, is 630 feet thick. The Transition Beds are approximately 380 feet thick at this locality.

Description	Thickness in feet	Feet above base
Loysburg Formation:		
Clover Member: 47.3' measured.		
R-78: Fossiliferous micrite; contains abundant ostracodes, also trilobites, gastropods, and brachiopods; medium dark gray.	2.5	665.3

Description	Thickness in feet	Feet above base
covered:	37.0	628.3
R-77: Algal mat biomicrite; finely laminated, small crowns observed; medium dark gray.	3.0	625.3
covered:	3.5	621.8
R-76: Ostracode-bearing disturbed algal mat biomicrite; contains tetradium (?); medium dark gray.	1.4	620.4
covered:	2.5	617.9
<u>Transition Beds</u>: 387.5 measured.		
R-75: Dolomitized micrite; shaly parting, very friable; medium gray.	4.0	613.9
covered:	1.3	612.6
R-74: Algal mat and ostracode-bearing intramicrudite; irregular wavy laminations on weathered surface; medium gray to light brownish gray.	1.5	611.1
covered:	1.2	609.9
R-73: Dolomitized algal mat biomicrite; medium gray to light brownish gray.	1.8	608.1
covered:	3.0	605.1
R-72: Intrasparite with minor amounts of oösparite; terrigenous clasts (extraclasts); medium gray.	1.0	604.1
covered:	1.0	603.1
R-71: Disturbed algal mat biomicrite; contains ostracodes; medium gray to light brownish gray.	2.0	601.1
covered:	19.0	582.1
R-70: Dolomitized algal mat biomicrite; medium gray.	3.0	579.1
R-69: Sparse algal mat biomicrite;	2.0	577.1

Description	Thickness in feet	Feet above base
irregular wavy laminations on weathered surfaces; medium dark gray to dark gray.		
R-68: Burrowed ostracode and trilobite-bearing intramicrudite; contains crinoids and brachiopods; contains blobs of hematite; weathers out to a "punky" limestone; medium gray.	2.4	574.7
R-67: Dolomitized micrite; mottled; massive; medium dark to dark gray.	8.0	566.7
R-66: Dolomitized dismicrite; brownish gray.	10.0	556.7
R-65: Fossiliferous micrite; contains ostracodes; prominent tiger-striped unit; medium to medium dark gray.	12.0	544.7
R-64: Mixed biomicrite; contains algal layers, ostracodes, trilobites, sponge spicules, and bryozoans; medium gray to light brownish gray; weathered surface shows a fucoidal pattern.	12.0	532.7
R-63: Dolomitized algal mat biomicrite; very rich in pyrite; massive appearing unit; medium dark gray.	4.0	528.7
covered:	2.1	526.6
R-62: Dolomitized dismicrite; burrowed; thin bands of intramicrite; light brownish gray.	1.5	525.1
R-61: Micrite; tiger-striped unit; medium gray to light brownish gray.	10.0	515.1
covered:	3.7	511.4
R-60: Burrowed ostracode and trilobite-bearing intramicrudite; minor amount of sparry cement; tiger-striped unit; brownish gray.	3.5	507.9
covered:	121.0	386.9

Description	Thickness in feet	Feet above base
R-56: Dolomitized algal mat biomicrite; light brownish gray.	4.5	382.4
R-55: Burrowed intramicrite; massive appearing unit; medium gray.	2.5	379.9
R-54: Algal mat biomicrite; poorly defined tiger-striped unit; medium dark gray; weathered surface shows a fucoidal pattern.	12.6	367.3
R-53: Intramicrudite and burrowed algal mat biomicrite; medium gray to light brownish gray.	3.4	363.9
R-52: Dolomitized disturbed algal mat biomicrite and intramicrudite; massive appearing unit; brownish gray.	4.9	359.0
R-51: Disturbed algal mat biomicrite with patches of intrasparite; finely laminated; medium dark gray.	3.8	355.2
R-50: Ostracode-bearing sparse biomicrite; poorly defined tiger-striped unit; medium dark gray; weathers to a creamy white.	3.6	351.6
R-49: Micrite; dolomitized in strips; grades into tiger-striped unit at top; medium gray.	3.3	348.0
R-48: Dolomitized burrowed algal mat biomicrite; massive appearing unit; medium dark gray.	4.5	344.7
R-47: Dolomitized disturbed algal mat biomicrite; light brownish gray to brownish gray.	2.1	342.6
R-46: Sparse algal mat biomicrite; medium dark gray.	9.5	333.1
R-45: Dolomitized intramicrudite; medium gray to brownish gray.	2.5	330.6
R-44: Trilobite and ostracode-bearing algal mat intramicrudite; medium gray; shows zones of cavity development; fucoidal weathering pattern.	1.8	328.8

Description	Thickness in feet	Feet above base
R-43: Burrowed algal mat biomicrite; flat algal mats separate yielding a sort of "shaly" parting;. medium gray.	1.9	326.9
R-42: Sparse intramicrudite; medium dark gray; weathers to a white.	2.3	324.6
R-41: Intramicrudite; medium gray.	7.9	316.7
R-40: Micrite with minor amounts of fine intrasparite layers containing ostracodes; medium dark gray.	1.0	315.7
R-39: Dolomitized intramicrite; shows small scale cross-bedding; massive appearing unit; pinkish gray to medium gray.	3.5	312.2
R-38: Dolomitized micrite; contains incipient rosebud concretions, less than 1 cm in diameter; massive appearing unit; medium gray.	3.5	308.7
R-37: Algal mat biomicrite; tiger-striped unit; incipient rosebud concretions; medium dark gray.	4.8	303.9
R-36: Mixed fossiliferous intramicrudite; contains crinoids, gastropods, trilobites, and ostracodes; medium gray to light brownish gray; fucoidal weathering pattern.	5.3	298.6
R-35: Burrowed intramicrite; very prominent tiger-striped unit, layers vary from less than 0.1' to approximately 0.3' thick, usually less than 0.1', breaks-up along these different layers similar to shaly parting; medium gray.	9.0	289.6
R-34: Dolomitized burrowed sparse intramicrite and algal mat biomicrite; massive appearing unit; vein filled by colloform hematite; medium gray to pinkish gray.	3.6	286.0
R-33: Dolomitized micrite; prominent dolomitized stringers; medium gray.	1.4	284.6

Description	Thickness in feet	Feet above base
R-32: Intramicrudite; massive appearing unit; medium dark gray.	1.5	283.1
R-31: Sparse algal mat biomicrite; minor amount of tiger-striped-like lithology; medium dark gray.	1.4	281.7
R-30: Sparse intramicrite; prominent tiger-striped unit; medium dark to dark gray.	3.1	278.6
R-29: Dolomitized micrite; patches of pyrite; dark gray.	1.7	276.9
R-28: Fossiliferous micrite; contains ostracodes and algal layers; medium gray.	1.2	275.7
R-27: Dolomitized algal mat biomicrite; medium gray to brownish gray; weathers to a creamy white.	1.3	274.4
R-26: Sparse algal mat biomicrite; medium dark gray.	3.8	270.6
R-25: Sparse algal mat biomicrite; medium dark gray.	0.8	269.8
R-24: Sparse ostracode biomicrite; prominent tiger-striped unit; medium dark gray.	4.6	265.2
covered:	2.7	262.5
R-23: Dolomitized algal mat intramicrudite; medium light gray to light brownish gray; grades into R-22.	1.3	261.2
R-22: Dolomitized burrowed algal mat biomicrite; massive appearing unit; medium gray.	1.6	259.6
R-21: Intrasparite intercalated with micrite; medium dark gray to brownish gray.	2.0	257.6
R-20: Intramicrite intercalated with micrite; medium dark gray.	1.8	255.8
R-19: Micrite intercalated with	1.9	253.9

Description	Thickness in feet	Feet above base
intramicrite; medium gray.		
R-18: Dolomitized intramicrudite; medium gray to light brownish gray.	3.7	250.2
R-17: Dolomitized micrite, minor amount of intrasparite; contains vugs of calcite; medium light gray.	2.3	247.9
R-16: Dolomitized micrite; medium gray.	2.2	245.7
R-15: Micrite, minor amount of intramicrite; massive appearing unit; brownish gray.	3.2	242.5
covered:	9.5	233.0
Bellefonte Dolomite: 231.0' measured.		
R-14: Dolomitized burrowed algal mat biomicrite with layers of intrasparite; massive appearing unit; light brownish gray.	2.0	231.0

samples randomly chosen from fairly continuous outcrop at _#_ feet above base

R-13: Dolomitized algal mat biomicrite; medium gray.	207.0
R-12: Dolomitized sparse algal mat intramicrite; very dense, hard rock; medium gray.	194.0
R-11: Dolomitized micrite; thin discontinuous stringers of limonite stain; light brownish gray to brownish gray.	172.0
R-10: Dolomitized sparse algal mat biomicrite; medium gray to brownish gray.	160.0
R-9: Dolomitized intramicrite; medium gray to brownish gray.	136.0
R-8: Dolomitized micrite; light brownish gray.	118.5

Description	Thickness in feet	Feet above base
R-7: Dolomitized sparse intramicrudite; pinkish gray.		117.0
R-6: Dolomitized burrowed algal mat biomicrite; laminations stand out well on weathered surface; medium dark gray.		90.5
R-5: Finely crystalline dolomite; laminations stand out on weathered surfaces; medium light gray.		73.0
R-4: Finely crystalline dolomite; light olive gray.		47.0
R-3: Finely crystalline dolomite; prominent cavernous zone; light olive gray.		17.5
R-2: Finely crystalline dolomite; light olive gray.		10.5
R-1: Dolomitized sparse intramicrudite, contains red stains; light brownish to brownish gray.		1.0

Loysburg Section

Everett Quadrangle, Pennsylvania (15 minute, 1937)

Latitude 40°08'15" N.
Longitude 78°23'30" W.

This section is situated along the east bank of Beaver Creek approximately a mile and a quarter south of the town of Loysburg on the east side of Route 36. The strata have a strike of about N. 14° E. and a dip of 39° to the southeast.

The lower end of the section begins at the junction of a dirt road which enters Route 36 from the east, just south of the school in the pasture south of the bridge crossing Beaver Creek. This lower end of the outcrop is in the Bellefonte Dolomite and the highest strata collected were part of the Hatter Formation, Eyer Member, which was encountered on the hillside overlooking the creek.

The strata that cropped out here were usually highly weathered and overgrown with vegetation, mainly moss. Two hundred and seventy feet of Transition Beds were measured at this locality, however, there may be as much as 350 feet as neither contact could be precisely established.

Description	Thickness in feet	Feet above base
Hatter Formation:		
L-1: Sandy intraclast-bearing mixed biosparite; contains abundant crinoid remains, plus brachiopods, trilobites and bryozoans; rich in hematite; medium gray.	2.2	442.4

Description	Thickness in feet	Feet above base
covered:	60.8	381.6
Loysburg Formation:		
Clover Member: 60.8 (covered).		
Transition Beds: 276.6' measured.		
L-2: Algal mat biomicrite and intercalated intramicrite; mottled; very thinly laminated; very rich in pyrite; medium dark gray.	1.0	380 6
L-3: Burrowed algal mat intramicrudite; medium dark to dark gray.	5.0	375.6
covered:	6.0	369.6
L-4: Disturbed algal mat biomicrite and intercalated intramicrite; contains ostracodes; silt-sized carbonate grains sorted into layers; medium dark gray.	3.0	366.6
covered:	4.0	362.6
L-5: Burrowed fossiliferous intramicrudite; numerous burrows; contains ostracodes; medium gray.	3.0	359.6
covered:	2.0	357.6
L-6: Sparse algal mat biomicrite; mottled; laminations stand out well on weathered surfaces; dark gray.	1.5	356.1
L-7: Dolomitized algal mat biomicrite; medium to medium dark gray.	3.4	352.7
L-8: Dolomitized algal mat biomicrite; mottled; medium gray.	4.0	348.7
covered:	1.0	347.7
L-9: Ostracode-bearing algal mat intramicrudite; medium gray; outcrop poor.	1.0	346.7
covered:	1.0	345.7
L-10: Ostracode and algal mat-bearing	2.0	343.7

Description	Thickness in feet	Feet above base
intramicrite; medium gray.		
L-11: Ostracode-bearing disturbed algal mat biomicrite; irregular vugs of spar approximately 1 mm in diameter; medium gray.	1.3	342.4
covered:	1.8	340.6
L-12: Disturbed algal mat biomicrite; contains patches of spar, resembles a dismicrite; light brownish gray to brownish gray.	2.0	338.6
L-13: Ostracode and trilobite-bearing micrite; brownish gray; weathers to a "creamy white."	0.8	337.8
L-14: Finely crystalline dolomite; mottled; medium gray to brownish gray.	2.5	335.3
L-15: Dolomitized disturbed algal mat biomicrite; concentrations of pyrite alternating with hematite; thin bedded; medium gray to brownish gray.	1.2	334.1
L-16: Dolomitized micrite; mottled; medium gray to light brownish gray.	2.4	331.7
L-17: Trilobite and ostracode-bearing disturbed algal mat biomicrite; medium dark gray.	4.8	326.9
L-18: Fossiliferous micrite; contains ostracodes; brownish gray; massive, weathers white.	1.8	325.1
covered:	3.0	322.1
L-19: Algal mat biomicrite and micrite; banded, bands 0.1 to 0.8' thick; medium gray.	3.2	318.9
L-20: Sparse algal mat biomicrite; medium gray to brownish gray.	2.5	316.4
L-21: Dolomitized intramicrite; mottled; peculiar red staining; patches of solid hematite after	1.8	314.6

Description	Thickness in feet	Feet above base
pyrite; medium gray to light brownish gray.		
L-22: Burrowed ostracode and trilobite-bearing intramicrudite; brownish gray; mottling caused by burrows seen on weathered surfaces.	2.6	312.0
covered:	1.0	311.0
L-23: Disturbed algal mat biomicrite; contains a few ostracode shells; medium dark gray.	2.8	308.2
L-24: Dolomitized disturbed algal mat biomicrite; red staining; medium gray to light brownish gray.	3.5	304.7
covered:	2.1	302.6
L-25: Mixed biomicrite; contains brachiopods, ostracodes and crinoid stems; medium dark gray.	0.6	302.0
covered:	1.5	300.5
L-26: Dolomitized algal mat biomicrite; contains crinoid stems; "cloud-like" dolomitization pattern; medium to medium dark gray.	2.5	298.0
L-27: Dolomitized disturbed algal mat biomicrite and intramicrite; appears to be burrowed; medium gray.	2.5	295.5
L-28: Intrasparite and micrite; medium dark gray.	2.0	293.5
covered:	2.8	290.7
L-29: Disturbed algal mat biomicrite; burrowed; "v-shaped" indentations in algal mat are due to desiccation, desiccation-cracks; medium gray.	1.5	289.2
L-30: Fossiliferous intramicrudite; contains ostracodes; medium dark gray; weathers to a creamy white; grades into L-31.	0.7	288.5

Description	Thickness in feet	Feet above base
L-31: Disturbed algal mat biomicrite; medium dark gray; grades into L-32.	0.7	287.8
L-32: Fossil-bearing intramicrudite; contains ostracodes, trilobites, and algal mats; rich in hematite; medium dark gray.	0.9	286.9
L-33: Micrite; medium dark to dark gray.	2.1	284.8
L-34: Ostracode and trilobite-bearing intramicrudite; dolomitized in strips; medium gray; burrowing probably causes fucoidal appearance on weathered surfaces.	4.4	280.4
L-35: Dolomitized ostracode and trilobite-bearing intramicrudite; heavily dolomitized in strips; medium dark gray.	1.2	279.2
L-36: Dolomitized micrite; layered; mottled; hematite in smears and thin irregular streaks; light brownish gray to medium gray.	2.0	277.2
L-37: Micrite and intercalated intramicrite; weathered surface shows a tiger-striped pattern; medium dark gray.	1.5	275.7
L-38: Dolomitized sparse intramicrite; exhibits rippled surface on polished face; banded; medium gray.	4.4	271.3
L-39: Dolomitized sparse biomicrite and intramicrite; mottled; irregular bands of hematite; light brownish gray to medium gray.	3.0	268.3
L-40: Algal mat biomicrite; contains ostracodes; "cloud-like" dolomitization pattern; fucoidal appearance on weathered surface; medium dark gray.	1.3	267.0
L-41: Dolomitized burrowed intramicrudite; rich in finely disseminated hematite; medium light gray to brownish gray.	3.5	263.5

Description	Thickness in feet	Feet above base
L-42: Dolomitized sparse intramicrudite; medium dark gray.	1.0	262.5
covered:	1.5	261.0
L-43: Dolomitized burrowed intramicrudite; medium gray.	4.5	256.5
covered:	3.4	253.1
L-44: Dolomitized algal mat-bearing intramicrudite; medium gray.	3.9	249.2
L-45: Dolomitized micrite; dolomite rhombs finer in size than the normal range; brownish gray to medium gray.	5.2	244.0
L-46: Dolomitized micrite; banded; medium dark gray.	11.0	233.0
L-47: Dolomitized micrite; dolomite rhombs coarser than usual, medium crystalline range; irregular streaks of concentrated hematite; medium dark gray to brownish gray.	2.0	231.0
L-48: Micrite; medium dark gray.	0.8	230.2
L-49: Dolomitized micrite; medium gray.	0.5	229.7
L-50: Dolomitized micrite; mottled; medium dark gray.	0.7	229.0
L-51: Intraclast-bearing sparse biomicrite; contains algal mats and ostracodes; tiger-striped unit in field; medium dark gray.	1.8	227.2
L-52: Dolomitized intraclast-bearing burrowed algal mat biomicrite; contains ostracodes; medium dark gray.	4.5	222.7
covered:	3.0	219.7
L-53: Dolomitized micrite; medium gray to medium dark gray.	0.5	219.2
covered:	2.0	217.2
L-54: Dolomitized dismicrite; medium	3.0	214.2

Description	Thickness in feet	Feet above base
gray to light brownish gray; grades into L-55.		
L-55: Intraclast-bearing sparse ostracode and algal mat biomicrite; prominent tiger-striped unit; medium dark gray.	7.0	207.2
L-56: Dolomitized sparse algal mat biomicrite; medium gray.	2.4	204.8
L-57: Dolomitized sparse intramicrite; shows small channels of hand specimen size; massive appearing unit; medium gray to light brownish gray.	2.4	202.4
L-58: Dolomitized sparse intramicrite; laminations stand out on weathered surfaces; medium dark gray.	2.5	199.9
L-59: Dolomitized micrite; banded; dark gray; approximately 0.3' relief at top and bottom of the unit.	4.3	195.6
L-60: Dolomitized sparse intramicrite; shows cross-bedding of fine clasts on hand specimen scale; finely disseminated hematite; light brownish gray.	3.9	191.7
L-61: Micrite; laminated; very thin bedded; medium dark gray.	2.0	189.7
L-62: Micrite; mottled; light brownish gray.	2.1	187.6
L-63: Oölite-bearing intrasparrudite; light brownish gray.	4.4	183.2
L-64: Sparse algal mat biomicrite; medium dark gray.	1.7	181.5
covered:	4.0	177.5
L-65: Sparse algal mat biomicrite; dolomitized in stringers; medium dark gray.	0.4	177.1
covered:	2.3	174.8

Description	Thickness in feet	Feet above base
L-66: Dolomitized micrite; medium dark gray.	1.6	173.2
L-67: Intramicrite intercalated with bands of micrite; channel in hand specimen, channel deposit exhibits graded bedding as do the intramicrite layers; light brownish gray to medium gray; weathers to a creamy white.	0.5	172.7
L-68: Dolomitized micrite and intercalated intrasparite; graded deposit in channel in hand specimen; light brownish gray.	1.5	171.2
L-69: Dolomitized micrite; banded; medium gray to light brownish gray.	8.8	162.4
L-70: Dolomitized sparse algal mat biomicrite; medium dark gray.	4.1	158.3
L-71: Dolomitized micrite; banded; prominent red staining; medium gray to light brownish gray.	3.9	154.4
covered:	12.0	142.4
L-72: Dolomitized sparse intramicrudite; medium gray to light brownish gray; resembles type Tea Creek lithology.	6.2	136.2
L-73: Dolomitized intramicrite intercalated with layers of intrasparite; light brown mottling; medium gray; resembles type Tea Creek lithology.	9.3	126.9
L-74: Dolomitized algal mat biomicrite; medium dark gray.	10.2	116.7
covered:	2.0	114.7
L-75: Dolomitized algal mat biomicrudite; medium gray to light brownish gray.	0.7	114.0
covered:	1.2	112.8
L-76: Algal mat-bearing	1.8	111.0

Description	Thickness in feet	Feet above base
intramicrudite; medium dark gray.		
covered:	12.0	99.0
Bellefonte Dolomite: 105.0' measured.		
L-77: Dolomitized algal mat-bearing biomicrite; "cloud-like" dolomitization pattern; medium light gray.	4.0	95.0
covered:	45.0	50.0
L-78: Dolomitized algal mat biomicrite; very thin bedded; medium gray.		45.0
L-79: Dolomitized micrite; mottled; light brownish gray.		25.0
L-80: Dolomitized micrite; dark gray.		10.0

Clover Creek Section

Martinsburg Quadrangle, Pennsylvania (7.5 minute, 1963)

Latitude 40°18'15" N.
Longitude 78°17'15" W.

This section was measured along Route 164 east of the town of Clover Creek. It begins approximately five hundred feet east of the location at which Route 164 crosses over Clover Creek. The strata crop out on the northeast side of the road. They strike N. 18° E. and dip 32° to the southeast.

The lowest strata found are assigned to the Transition Beds, 148 feet of which are exposed at this locality. The upper contact, between the Transition Beds and the Clover Limestone, is readily determined. The lower 55 feet of this section is discontinuous, while the upper portion contains almost no covered intervals.

Description	Thickness in feet	Feet above base
Loysburg Formation:		
Clover Member: 14.2' measured.		
C-33: Intraclast-bearing mixed biomicrite; contains ostracodes, trilobites, gastropods, bryozoans, and crinoids; medium dark gray.	3.0	150.9
C-32: Burrowed algal mat biomicrite; very thin bedded; medium gray.	5.0	145.9
covered:	1.0	144.9
C-31: Dolomitized disturbed algal mat biomicrite; medium gray.	0.4	144.5

Description	Thickness in feet	Feet above base
covered:	0.6	143.9
C-30: Dolomitized micrite; mottled by dolomitization; massive appearing unit; light brownish gray.	2.2	141.7
C-29: Mixed biomicrite; very fossiliferous, mostly ostracodes with trilobites, crinoids, bryozoans, and corals (?); tiger-striped unit; medium dark gray.	2.0	139.7
Transition Beds: 139.7' measured.		
C-28: Dolomitized sparse intramicrite, grades upward into an intramicrite; medium dark gray.	6.5	133.2
C-27: Ostracode-bearing intramicrudite; faintly tiger-striped near top; brownish gray.	2.0	131.2
C-26: Algal mat biomicrite and algal mat intramicrite; medium gray.	2.8	128.4
C-25: Disturbed fossiliferous intramicrudite; contains ostracodes and algal layers; medium dark gray.	0.6	127.8
C-24: Algal mat biomicrite intercalated with thin intramicrite bands; contains a few ostracodes; medium gray; creamy white weathered surfaces.	3.4	124.4
C-23: Fossiliferous intramicrudite; contains ostracodes, trilobites, and algal layers; exhibits red staining; medium gray to light brownish gray; fucoidal weathering pattern.	3.3	118.1
C-22: Sparse mixed biomicrite; contains ostracodes and algal layers; brownish gray; weathers to a light gray.	2.0	116.1
C-21: Dolomitized sparse algal mat biomicrite; massive appearing unit; medium dark gray to brownish gray.	5.5	110.6
C-20: Dolomitized algal mat biomicrite; banded; medium dark gray.	3.0	107.6

Description	Thickness in feet	Feet above base
covered:	5.3	102.3
C-19: Dolomitized burrowed algal mat biomicrite; massive appearing unit; medium gray.	2.8	99.5
C-18: Dolomitized intramicrite; pinkish gray.	6.0	93.5
C-17: Dolomitized burrowed micrite and layers and pockets of intramicrite; medium dark gray.	6.0	87.5
covered:	3.5	84.0
C-16: Dolomitized intercalated algal mat biomicrite and fine and coarse intramicrite; banded; brownish gray.	2.5	81.5
C-15: Dolomitized micrite; medium gray.	4.0	77.5
covered:	2.8	74.7
C-14: Fossiliferous intramicrudite; contains ostracodes; tiger-striped unit; medium dark gray.	4.2	70.5
C-13: Dolomitized intramicrite intercalated with dolomitized micrite; banded; medium gray to brownish gray.	2.2	68.3
C-12: Dolomitized intramicrite; medium dark gray; resembles type Tea Creek lithology.	0.8	67.5
C-11: Dolomitized burrowed and mud-cracked algal mat biomicrite; banded; medium dark gray.	8.4	59.1
C-10: Dolomitized algal mat intramicrudite; mottled; clasts well rounded; medium gray.	2.5	56.6
C-9: Dolomitized algal mat intramicrite; banded; medium light gray.	3.8	52.8
covered:	14.0	38.8
C-8: Dolomitized sparse intramicrite; medium dark gray.	1.2	37.6

Description	Thickness in feet	Feet above base
covered:	3.5	34.1
C-7: Dolomitized intramicrite; medium dark gray.	2.0	32.1
covered:	11.5	20.6
C-6: Micrite; medium dark gray.	0.6	20.0
covered:	1.3	18.7
C-5: Dolomitized micrite with laminations of dolomitized intrasparite; finely layered; brownish gray.	0.7	18.0
covered:	6.0	12.0
C-4: Intramicrudite; medium gray to light brownish gray.	2.3	9.7
C-3: Micrite; mottled; thin-bedded; medium dark gray; fucoidal weathering pattern.	2.0	7.7
C-2: Sparse intramicrite; tiger-striped unit; medium dark gray.	6.0	1.7
C-1: Dolomitized intramicrite; finely laminated; light brownish gray.	1.7	0.0

Belleville Section

Lewistown Quadrangle, Pennsylvania (15 minute, 1927)

Latitude 40°36'30" N.
Longitude 77°44'45" W.

This locality consists of three separate outcrops.

A good exposure of both members of the Bellefonte Dolomite, Coffee Run and Tea Creek Members, exists in the Union Township Quarry. This quarry is situated in the town of Belleville and is found by entering the parking lot west of the Belleville bank and going through a farm yard towards the west. The quarry is directly south of a small stream, Little Kishacoquillas Creek. The contact between the Coffee Run and Tea Creek Members can be found on the east side of the quarry. Samples B-1 through B-5 were collected in the quarry.

The Transition Beds crop out in a small field on the north side of Route 305 west of the town of Belleville. The outcrop begins in a field just west of Little Kishacoquillas Creek and extends westward. The total thickness of strata is approximately 35 feet, samples B-6 through B-13 were collected at this site. It was at this locality that abundant trilobite remains were found.

Transition Beds also crop out approximately 250 feet to the west, 18 feet of section is exposed on this hillside, samples B-14 through B-19. The contact between the Clover Limestone and the Transition Beds lies buried between this outcrop and the strata which crop out along

Route 305 to the west, a distance of 150 feet, specimen B-20 was collected from the lower portion of the Clover Limestone along Route 305.

Description	Thickness in feet	Feet above base
Loysburg Formation:		
Clover Member:		
B-20: Mixed fossiliferous intramicrudite; contains crinoids, bryozoans, ostracodes and gastropods; dark gray.		
covered:		
Transition Beds:		
B-19: Dolomitized disturbed algal mat biomicrite; medium gray to light brownish gray.	4.0	14.0
B-18: Algal mat biomicrite near base grading up into an intramicrudite; medium gray.	3.5	10.5
B-17: Dolomitized algal mat biomicrite; very dense rock; medium to medium dark gray; weathers to a light brownish gray.	3.0	7.5
B-16: Ostracode-bearing burrowed dismicrite; thoroughly churned; brownish gray; fucoidal weathering pattern most likely due to burrowing.	3.0	4.5
B-15: Dolomitized intramicrite; mottled; some portions are finely laminated; medium gray to brownish gray.	3.0	1.5
B-14: Disturbed algal mat intramicrudite; medium dark gray to brownish gray; very finely laminated on weathered surface.	1.5	0.0
covered:		
B-13: Fossiliferous intramicrudite;	4.0	31.3

Description	Thickness in feet	Feet above base
algal layers intercalated with intramicrite zones; red staining; medium gray.		
B-12: Disturbed algal mat biomicrite and intramicrudite; appears to have burrowed zones; contains abundant trilobite fragments approximately 4' above base of unit; also contains ostracodes and brachiopods; prominent tiger-striped unit; medium dark gray.	12.0	19.3
B-11: Algal mat biomicrite; contains some ostracodes; massive appearing unit; medium light gray to light brownish gray.	2.5	16.8
B-10: Sparse algal mat biomicrite; prominent tiger-striped unit; medium dark gray.	2.0	14.8
B-9: Sparse intrasparite intercalated within a micrite; medium dark gray.	5.5	9.3
covered:	1.5	7.8
B-8: Sparse intrasparite intercalated within a micrite; medium dark gray to brownish gray; weathers to a white with algal laminations showing on the weathered surface.	2.0	5.8
B-7: Dolomitized micrite; massive appearing unit; medium gray; weathers to a creamy white.	2.5	3.3
B-6: Dolomitized fossiliferous sparse intramicrudite; algal laminations; light gray to light brownish gray.	3.3	0.0
covered:		
Bellefonte Dolomite:		
B-5: Dolomitized sparse algal mat biomicrite; medium gray.		75.0
B-4: Dolomitized sparse intramicrudite;		45.0

Description	Thickness in feet	Feet above base
light gray.		
B-3: Dolomitized algal mat biomicrite; medium gray.		20.0
B-2: Dolomitized sparse intramicrite; medium dark gray.		10.0
B-1: Dolomitized intramicrudite; medium gray.		0.0

PLATE 1

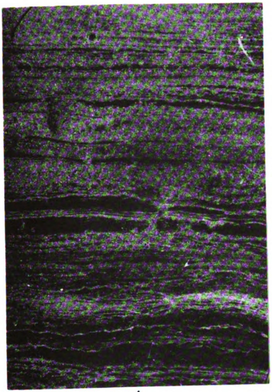
Figure

1. Sample R-43; typical peel of algal mat, exhibits irregular, crenulated layers often disrupted (negative print, X4).

2. Sample S-15; peel of crenulated algal layers overlain by an intramicrudite (negative print, X4).

3. Sample L-74; peel of algal mat exhibiting selective dolomitization of thin algal layers (negative print, X4).

PLATE I



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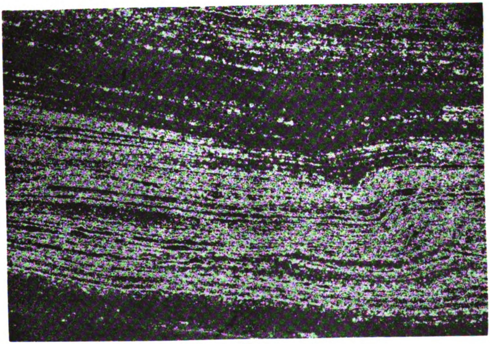

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PLATE 2

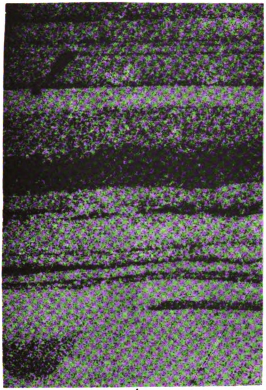
Figure

1. Sample L-68; peel shows channel, lower left, which has a graded deposit, dark areas are cemented by spar, the rest of the material is micrite; grading is prominent in the center of the photograph (negative print, X4).

2. Sample L-40; an example of the "cloud-like" dolomitization pattern, readily distinguishable burrows in the lower portion of the photograph (negative print, X4).

3. Sample L-32; abundance of shell material, dark patches, in "placer-like" deposit (negative print, X4).

PLATE 2



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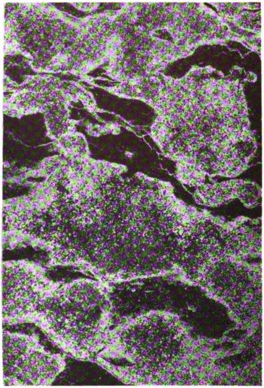

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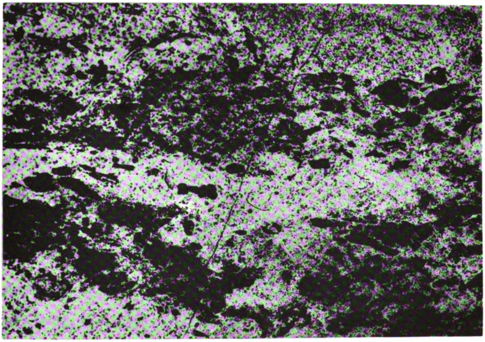

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APPENDIX II

INSOLUBLE RESIDUE ANALYSIS

Insoluble residue analyses were performed on the samples collected from the Sparr Quarry locality. The scheme used in the analyses is outlined below.

The weathered edges of the rock were removed before treatment so that only fresh rock was used for the residue analysis. Each sample was cut into slabs approximately ¼" thick; this procedure facilitated crushing of the rock into particles between one-fifteenth and one-fifth of an inch in diameter. This increased the surface area and as a result increased the rate of reaction between the acid and the carbonate.

Fifty grams of crushed rock was placed in a beaker along with a 5% solution of muriatic acid. As effervescence ebbed, small quantities of muriatic acid were added to the beakers. The mixture was stirred periodically to increase the rate of reaction. Mixtures in which the reaction proceeded slowly were warmed. Dissolution of the carbonate portion of the specimen was considered complete when addition of fresh acid did not result in a renewal of effervescence. As a check, a fresh piece of calcite was dipped into the mixture to determine whether the solution was capable of reacting with any undissolved carbonate. The process of dissolution took about a day and a half to complete.

The residue was then collected by filtration. After the entire contents of the beaker was collected on the filter paper the residue was thoroughly washed with warm water. This washing removed all traces of muriatic acid and the precipitate which formed as a result of heating the mixture. The precipitate is believed to be anhydrite. The residue and filter paper were dried in an oven at a temperature of 110°F for a period in excess of 48 hours. Both were cooled to room temperature and weighed. The weight of the filter paper had been previously determined and recorded. At both of these weighings two control pieces of filter paper were also weighed and recorded. In order to determine an accurate weight it was necessary to consider the effect of changes of the atmospheric humidity between weighings of the filter paper. This was necessary due to the rapid rate with which filter paper was found to adjust to atmospheric conditions by absorption or transpiration of water. This was accomplished by using the two control pieces of filter paper, which were constantly left exposed to the conditions in the laboratory. It was possible to determine whether the filter paper had gained or lost weight and to correct for this factor when weighing the residue with the filter paper. This procedure made possible the calculation of the total insoluble residue and the percentage of insoluble residue in the treated samples.

The next step required a removal of the fine-grained part of the residue. To accomplish this the residue was washed from the filter paper into a beaker. Calgon was added to the mixture to aid in separating the fines from the coarse particles. The mixture was stirred vigorously and left to stand for one minute. After this period of time elapsed the mixture was decanted; the fine-grained portion was discarded. This process was repeated until the water appeared free of particles in suspension after mixing.

The contents of the beaker were then filtered. The residue was again dried in an oven and its weight calculated using the same control technique as described above. The percentage of both the coarse-grained residue and fine-grained residue to the total residue was calculated. The results are listed on the following page.

INSOLUBLE RESIDUE ANALYSIS OF SPECIMENS FROM SPARR QUARRY

Sample	Percentage residue by weight			Sample	Percentage residue by weight		
	Total	Coarse	Fine		Total	Coarse	Fine
1	3.37	0.45	2.92	32	22.63	13.81	8.82
2	12.94	0.08	12.86	33	5.63	0.01	5.62
3	8.72	0.12	8.60	34	5.06	0.15	4.91
4	8.50	0.51	7.99	35	4.53	0.42	4.11
5	11.22	0.10	11.12	36	9.27	0.11	9.16
6	8.20	0.52	7.68	37	10.03	0.17	9.86
7	4.77	0.08	4.69	38	0.54	0.52	0.02
8	5.17	0.40	4.67	39	16.12	6.85	9.27
9	3.73	0.22	3.51	40	21.24	13.22	8.02
10	15.44	2.03	13.41	41	12.20	1.84	10.36
11	7.47	0.09	6.38	42	19.16	9.32	9.84
12	16.68	6.72	9.96	43	6.82	0.75	6.07
13	15.46	2.34	13.12	44	5.56	0.24	5.32
14	17.92	6.48	11.44	45	7.36	0.34	7.02
15	13.50	0.84	12.66	46	13.25	0.54	12.71
16	11.93	0.82	11.11	47	31.07	24.88	6.19
17	9.04	0.24	8.80	48	8.91	2.02	6.89
18	13.46	2.22	11.24	49	2.34	0.11	2.23
19	7.92	0.26	7.66	50	2.82	0.14	2.68
20	4.08	0.01	4.07	51	4.15	0.08	4.07
21	22.89	0.06	22.83	52	7.86	1.13	6.73
22	4.20	0.94	3.26	53	18.91	14.34	4.57
23	10.33	0.04	10.29	54	6.13	0.55	4.58
24	2.89	0.02	2.87	55	4.73	0.17	4.56
25	5.07	0.01	5.06	56	7.32	1.30	6.02
26	7.18	0.34	6.84	57	5.28	0.86	4.42
27	16.54	10.87	5.67	58	7.43	0.21	7.22
28	4.57	0.07	4.50	59	11.63	4.45	7.18
29	7.25	0.28	6.97	60	13.99	6.94	7.05
30	5.31	0.08	5.24	61	6.14	0.78	5.36
31	12.69	0.80	11.89	62	4.23	0.99	3.24

PLATE 3. INSOLUBLE RESIDUE HISTOGRAM - BED BY BED

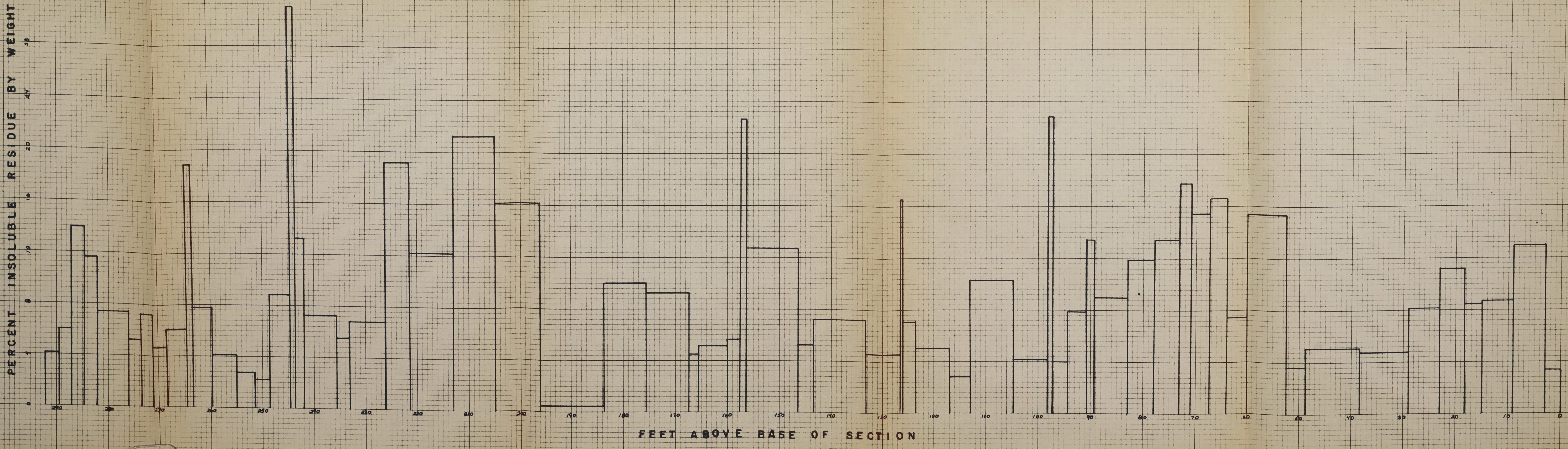

PLATE 4. INSOLUBLE RESIDUE HISTOGRAM - PLOTTED AT FIVE-FOOT STRATIGRAPHIC INTERVALS

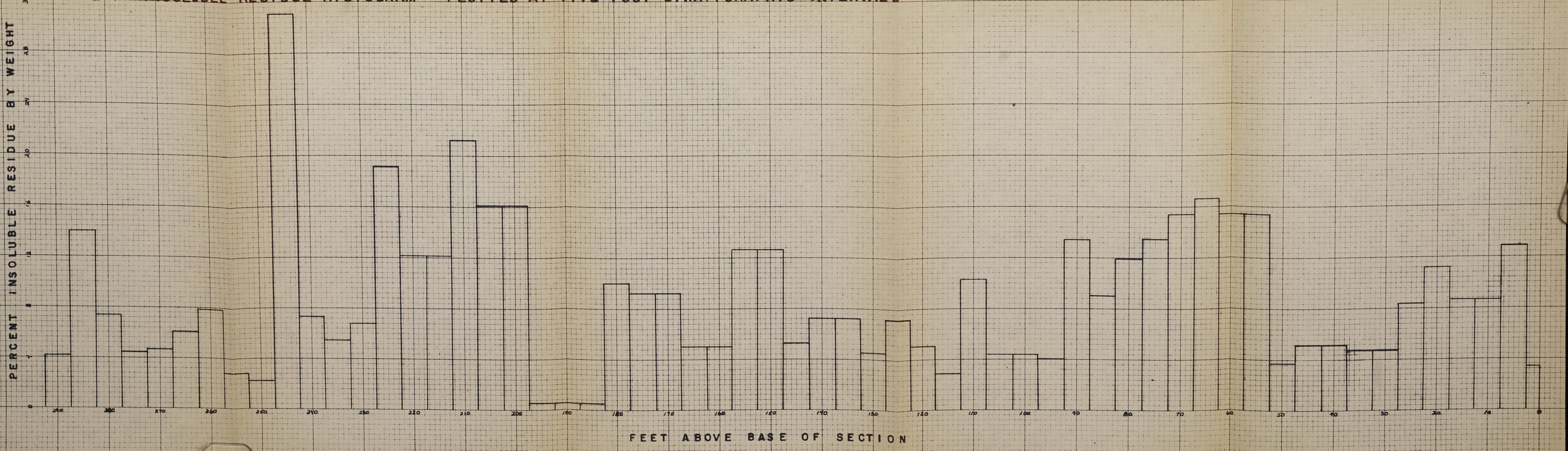

PLATE 5. INSOLUBLE RESIDUE HISTOGRAM — PLOT OF MOVING AVERAGE OF THREE READINGS AT FIVE-FOOT STRATIGRAPHIC INTERVALS