LOWER PALEOZOIC CARBONATES: GREAT VALLEY

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INTRODUCTION

The purpose of this field trip is to demonstrate the subdivision of the Cambro-Ordovician carbonate sequence as proposed by the field trip leaders. In addition, there will be discussions on environmental, hydrogeologic, and engineering problems in these carbonates and how this subdivision has "opened the doors" in understanding how everyday problems from man's activities can affect or be affected by certain lithic units within the carbonate sequence. This understanding of the interaction between man's activities and how it might affect or be affected by critical aquifers, thin or thick soil horizons, and specific lithologies by septic waste loads, ground water pollution, building foundation loading, landfills, etc., has become extremely important in the land development process.

We anticipate this field trip will not only relate the carbonate subdivision but will point out how important this breakdown is to applied geology.

"KITTATINNY LIMESTONE"

Weller (1900) used the general term "Kittatinny Limestone" for Cambro-Ordovician carbonate rocks of northern New Jersey and identified them with similar units in Virginia, Maryland, Pennsylvania and New York. In his "Annual Report of the State Geologist 1900," page 4, he states, "This limestone formation has a great thickness which is estimated at from 2,700 to 3,000 feet. It is designated the Kittatinny Limestone because it is the great limestone formation of the Kittatinny Valley..."

LEITHSVILLE FORMATION

Although there are no scheduled stops at Leithsville Formation outcrops (because of no exposures on or adjacent to Route 80) on the trip, a short description of the Leithsville Formation is included in order to better understand the Lower Paleozoic carbonate ("Kittatinny") group for this guidebook. (see Table 1)

The Lower Cambrian Leithsville Formation named by Wherry (1909) in Pennsylvania is the equivalent of the Tomstown Formation described by Miller and others (1939) in eastern Pennsylvania and New Jersey.

Avery Drake, (1961, 1967b) mapped the Leithsville Formation on the Frenchtown and Bloomsbury Quadrangles and Markewicz (1967) used the term Leithsville on the High Bridge Quadrangle. Wherry (1909) assigned a Lower-Middle Cambrian age to the Leithsville, whereas Willard (1961) infers that it is Middle Cambrian. No fossil evidence had been found to establish its age until the discovery of the Lower Cambrian fossil *Hyolithellus micans* in the early part of the 1960's, Markewicz (1964 unpublished), in rubbly dolomitic beds of the basal Leithsville at Califon, New Jersey and also near Monroe in southern New York State. In addition, the fossil *Archaeocyathus* occurs in basal Leithsville dolomite at Franklin, Califon and Wantage in New Jersey and at Easton, Pennsylvania. It is most prolific immediately above the Hardyston-Leithsville contact but has also been noted in the lower part of the Wallkill Member. A recent paper by Palmer and Rozanov (1976) describes the original *Archaeocyathus* found in New Jersey by George Banino at Franklin.

The Leithsville Formation is subdivided into three members, based upon field work by Markewicz 1964-68 and Markewicz and Dalton 1968-72. These members are in descending order:

Wallkill Member
Hamburg Member
Califon Member

Califon Member

The Califon Member is the basal Leithsville unit and is named after the *Hyolithellus micans* and *Archaeocyathus* bearing dolomite exposed in an abandoned

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SUBDIVIDISION OF THE KITTATINNY LIMESTONE

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<tr><th></th><th>Formation Name Used on N.J. Geol. Map</th><th>Formations Recognized by H. B. Kummel and Others</th><th>Formations Recognized by A. A. Drake and F. J. Markewicz</th><th colspan="3">Current Stratigraphy As Used by F. J. Markewicz and R. F. Dalton</th></tr>
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<tr><td colspan="2">Big Springs mbr.</td></tr>
<tr><td colspan="2">Branchville mbr.</td></tr>
<tr><td rowspan="2">Rickenbach</td><td rowspan="2">Rickenbach Formation</td><td>Hope mbr.</td><td rowspan="2">Crooked Swamp Dolomite Facies</td></tr>
<tr><td>Lower mbr.</td></tr>
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<tr><td colspan="2">Limeport mbr.</td></tr>
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quarry near Califon, New Jersey. In New Jersey the member measures from 40 to 150 feet thick, but typically averages 100 feet thick.

It consists essentially of two distinct lithologies:

(1) The upper section, varying from 20 to 50 feet thick consists of: very fine to cryptogranular, light gray to locally light greenish gray, dense, sharp breaking, locally laminated dolomite, in beds 6″ to 20″ thick.

(2) The lower section can be 20 to 100 feet (thickness dependent on locality and depositional environment) and varies from gray to dark gray, sparkly to dull, fine to medium megacrystalline, strongly stylolitic, patchy textured dolomite.

Discontinuous pyritic seams, masses, lenses or clots are typically present, especially in the lower part of the section.

Hamburg Member

The type section for the Hamburg Member is located approximately one-half mile southwest of the town of Hamburg, where it forms a sharp, razorback hill. At this locality it is approximately 85 to 100 feet thick. The underlying Califon Member can be seen at several locations here. It is less than 40 ft. thick.

Typically, the member is best described as a rhythmically bedded sequence of sedimentary cycles, representative of mud flat to intertidal and lagoonal environments. The member is estimated to be from 35 to over 100 feet thick, depending upon locality and depositional environment. The overall lithology at any given exposure will generally consist of one of the following types:

(1) Dark, organic, ribbony to laminated to very thinly bedded, cryptogranular to very fine grained dense dolomite and shale with intercalated, thin siltstone and fine sandstone beds, lenses or stringers.

(2) Dark to light gray, locally brownish gray to green cyclical units of fine to coarse sandstone, (locally quartzitic) siltstone, shale and very fine grained to cryptogranular, dense, conchoidal-breaking dolomite. Lithology sequence is typically coarse to fine upward, and siliceous to calcareous upward.

(3) Thinly bedded to ribbony, brown to bright red, sometimes as or intercalated with green shales, siltstones and sandstones, or low grade orthoquartzites.

(4) Brownish weathering, thinly bedded, to strongly laminated siliceous to calcareous phyllite intercalated with local lense-like laminated dolomite and chert. This is the "damourite shale" unit as described in the early reports on the "Kittatinny" of New Jersey.

The contact with the overlying Wallkill Member, though rarely exposed is gradational upward from the Hamburg.

Wallkill Member

The Wallkill Member which overlies the Hamburg Member forms the upper part of the Leithsville Formation. It is poorly to rarely exposed, because it generally forms a topographic low in stream valleys or other low-lying areas.

The Wallkill Member is named after the dark gray, patchy dolomite that lies above the shaly, arenaceous Hamburg Member on the east side of the Wallkill Valley north of Hamburg. Here the lower part consists of fine to medium grained, rubbly to lumpy bedded, stylolitic, locally vuggy, mottled, patchy to ruditic textured, sparkly dolomite in beds from several inches to more than 1.5 feet thick. The lower part of the unit is similar in depositional environment and lithology to the lower Califon Member.

The upper part consisting of fine to medium-grained, locally coarse crystalline dolomite with some beds of algal like structures and large oolites and pisolites appears to be transitional into the lower part of the Limeport Member of the Allentown Formation. The Wallkill Member is estimated to be from 350 to 500 feet thick.

The lower part of the Wallkill, the entire Hamburg and Califon Members are considered to be potential sulfide-bearing horizons. Sphalerite, galena, fluorite, and some chalcopyrite have been found at several localities. The Austinville, Virginia zinc deposit probably occurs in the lower equivalent (?) of the Leithsville Formation.

ALLENTOWN FORMATION

The name Allentown was proposed by Wherry (1909) for the thick sequence of oolitic dolomite overlying the Leithsville in eastern Pennsylvania. B. L. Miller and others (1939) mapped the Allentown in the Lehigh Valley using the name Conococheague instead of Allentown. Later he reverted to the local name. Howell and others (1950) subdivided the Allentown into the Limeport and Allentown Formations.

Drake (1965) did not follow the twofold subdivision of the Allentown, instead he mapped the entire sequence as a single unit, the Allentown Formation.

In New Jersey, two mappable units are recognized within the Allentown. For the lower member, the name "Limeport" was reintroduced (1977) having been redefined on the basis of lithic and sedimentary features. The upper member is referred to as the Upper Allentown Member. Additional work is necessary to further define any lithic and fossil definitions.

Limeport Member

The Limeport Member lying above the Wallkill Member of the Leithsville Formation, consists of fine to medium crystalline, cyclically bedded, light to dark gray dolomite in beds from several inches to more than two feet thick. Oolites, crypotozoa, ripple marks, mud cracks, cross bedding and chip conglomerates predominate the member. Many forms of algal structures are present, ranging from thin mats to large thick colonies.

The Limeport Member varies from 300 to 700 feet thick through most of New Jersey. In the northwestern portion of the state, the unit thickens greatly at the expense of the upper member.

The transition zone between the upper member and the Limeport is gradational with oolites and cryptozoa becoming less abundant going upward. The field contact is placed at the last common appearance of cryptozoa and oolites and the appearance of uniformly textured, thick bedded dolomite.

Upper Allentown Member

The Upper Allentown Member is equivalent to the Allentown Formation as defined by Howell and others (1950). In the Hamburg area it is 1,000 to 1,200 feet thick. In northwestern New Jersey the upper member thins to less than 500 feet thick, due to a thickening of the Limeport Member.

The Upper Allentown is much more massive and thick-bedded than the Limeport Member. The beds, from one to six feet in thickness, vary from very fine to medium crystalline, light to dark gray dolomite with some beds being finely laminated. Chert and sandy units are much less frequent than in the Limeport. In contrast to the Limeport, stromatolites and oolite beds are infrequently found. The contact between the Allentown and the overlying Rickenbach is placed at an undulating scour and fill quartzitic conglomerate zone located about 75 feet above a distinct section of thin bedded, mottled dolomite containing local lenses or thin bands of oolites, cryptozoa, and silt beds.

RICKENBACH FORMATION

The Rickenbach Formation is subdivided into two members, an upper (Hope) member and a lower (unnamed) member along with a distinct lithic facies named the Crooked Swamp Dolomite.

Lower Member

The lower member consists of mostly thin to medium-beds, cream to dark gray weathering dolomite. Some are massive, mottled and weather to a raspy feeling surface. The texture is mostly fine to medium-grained with some coarse grained beds containing pits and clots. There are beds of chip conglomerate as well as sandy dolomites and local quartzites. Some beds consist of a purplish light gray dolomite. Lenses, knots and beds of chert can be present. Pyrite can be found throughout the section. The member varies in thickness from 75 to 150 feet and at the Rt. 80 section it is 125 feet thick.

The transition between the lower member and the Hope Member is gradational with the rock becoming darker and finer grained going upward from the lower member.

Hope Member

The Hope Member consists of light to gray, weathered, aphanitic to finely crystalline, medium-bedded dolomite which is interbedded with darker gray, weathered medium to coarsely crystalline, medium to massive-bedded dolomite. Many of the aphanitic beds contain a sandy zone at the base. The coarser beds can contain clots of quartz and white dolomite. At some locales a very distinctive internal brecciation or crackling is most probably related to the paleo-karstification of the Cambro-Ordovician sequence at the end of the Beekmantown.

Several chert beds and zones are found in this member one of which forms a distinctive marker horizon that can be traced from New York to Pennsylvania. This bed, which we have termed the "7 cherts" is a second higher or upper zone of knots and lenses of chert, some convex. Algal structures occur in and above this zone.

The contact between the Rickenbach and the Epler Formations is generally placed about 50 feet above the upper chert horizon. The Hope Member at its type locality on Route 80 is 167 feet thick.

Crooked Swamp Dolomite Facies

The Crooked Swamp Dolomite facies consists of a light to light gray, fine to coarse, euhedral grained dolomite and is best developed near Crooked Swamp, north of the town of Lafayette, Sussex County. The individual dolomite crystals can be surrounded by a fine clay-like material. Many of the beds contain clots and pits which are commonly filled with dolomite, quartz and kaolinite. The beds range from two to six feet in thickness and algal structures can be present.

At the type section this facies approaches 150 to 200 feet in thickness and it thins rapidly both north and south to less than 25 feet. As the unit thins a distinctive conglomerate is developed in the upper Rickenbach and lower Epler. The Crooked Swamp facies may represent a series of reef structures.

Samples of the Crooked Swamp Dolomite have been compared to the Kingsport Formation of eastern Tennessee and cannot be separated by visual examination. The basal part of the Epler where the conglomerate is developed is lithologically similar to the Mascot Dolomite of eastern Tennessee. The Mascot and Kingsport occupy a similar stratigraphic interval as the Epler and Rickenbach.

EPLER FORMATION

The Epler Formation as defined by Hobson (1963) consists of an interbedded sequence of dolomite and limestone with the contact between the Rickenbach and the Epler being placed at the lowest limestone bed. Drake (1965) places the upper contact at the unconformity with the Jacksonburg. Drake (1969, p. 87) states that "The Ontelaunee of Pennsylvania is absent in the Delaware Valley..." In the outcrop area northeast of where Drake worked the Epler is mainly a dolomite except for occasional limestone lenses which occur in the middle part of the formation.

The Epler Formation has been subdivided into three members (Markewicz and Dalton 1977). These are in descending order:

Lafayette Member
Big Springs Member
Branchville Member

Branchville Member

The contact between the Rickenbach and the Branchville Member is generally placed at a massive chert bed. This member usually will consist of two distinct lithic units. The lower one ranges from 0 to 50 feet in thickness and is a variable sequency of fine to coarse-grained, light to dark gray, medium to massive-bedded dolomite. Laminations may be present along with chert, shale, oolites and cryptozoa. At some localities, the lower most part consists of a reddish, pinkish and/or greenish cryptocrystalline sandy dolomite with some white porcelainite-like chert.

The upper part of the member is a 150 to 200 feet thick, very fine to fine grained, medium to dark gray, very massive, finely laminated dolomite with occasional thin siliceous to shaly interbeds. The rock generally weathers to a reddish brown to buff color.

Big Springs Member

The Big Springs Member is a 40 to 150 feet thick section of variable dolomites and limestones with very pronounced shaly to siliceous interbeds. In the type area, near Hamburg, the Big Springs generally consists of a light to medium gray, fine to medium grained dolomite with local green to pink beds, bands or lenses of siliceous dolomite, quartzite or shale. The dolomite beds are from one to three inches thick with the shaly and quartzitic interbeds being one-quarter to one inch thick. The siliceous beds weather in strong relief giving the rock a ribbed appearance. Cross bedding, chip conglomerates, cut and fill, oolites, chert and red and green argillitic dolomite can be present. The rock weathers with a distinctive bright red to yellow-orange rind and some of the interbeds weather to porous, siliceous ribs. This unit generally will show more evidence of deformation than the members above or below. Chevron folding is common as are torn and rolled beds.

In the northeastern portion of the outcrop at Hamburg there may be occasional limestone lenses of limited areal extent which may replace all or part of the unit although the distinctive sedimentary features are usually retained. The limestone weathers to a powder blue color with green or red-brown siliceous interbeds. From Newton, southwest toward the Delaware River, the Big Springs Member is predominantly a limestone which can change both laterally and vertically to a dolomite in many outcrops. The dolomite lenses are generally encased by a siliceous rind. In the Paulins Kill Valley west of Blairstown the limestone extends both above and below the Big Springs.

Lafayette Member

The Lafayette Member ranges from 50 to 250 feet in thickness and is almost identical to the Branchville Member. Two recognizable units occur within the member. The lower portion is generally a fine to medium grained, black, sparkly, massive-bedded dolomite that contains some beds of light to medium gray, fine grained dolomite with shaly laminations. The fine grained beds weather to an orange-gray color. Chert can be present along with some siliceous beds. The upper part of the member is a finely laminated, massive, light to medium gray, very fine to fine grained, cream to orange-gray weathering dolomite. The laminations stand out in relief on the weathered surface. Chert occurs in beds and clots. The Lafayette Member is transitional with the overlying Ontelaunee Formation through a sequence of medium gray, very fine grained, laminated dolomite to medium gray slightly sparkly, fetid dolomite. The Lafayette Member contains massive zones of breccia which will be discussed in the section on the paleosolution breccia.

ONTELAUNEE FORMATION

The Ontelaunee Formation was recognized in New Jersey by Dalton and Markewicz (1972), Markewicz and Dalton (1974 and 1976). Field work on the Ontelaunee in Pennsylvania by Markewicz during 1965-66 indicated that it is similar with the upper part of the "Kittatinny" in New Jersey. Hobson (1963, p. 75), in referring to the Ontelaunee, states that "A mappable unit of dolomite has not been recognized to date in the Lehigh River and Delaware River areas..." Drake (1969, p. 87), also, does not recognize the Ontelaunee in New Jersey.

The thickness of the formation is dependent on the amount of erosion during the Knox-Beekmantown Unconformity. At Sarepta Quarry, in Warren County there is evidence for over 200 feet of erosion in a very short distance. In the Phillipsburg area the Ontelaunee probably exceeds 800 feet in thickness. The formation has been divided into the following members:

Harmonyvale Member
Beaver Run Member

Beaver Run Member

The Beaver Run Member is 150 to 200 feet thick and contains three recognizable units. The lower part, about 50 feet thick, is a massive, medium to coarsely crystalline, black, sparkly, fetid dolomite. The individual euhedra are characteristically zoned.

Some laminated beds, along with a little chert, can be present. Above this is a 50 to 100 feet thick, massive dolomite similar to the lower part, except that there is a large amount of bedded, anastomosing, rugose, and knotted chert. Individual chert beds can be as much as ten feet thick. Many silicified fossils have been found in this section. The upper portion, which can be as much as 50 feet thick, is a massive, fine to medium grained, black, sparkly, fetid dolomite, generally with little chert.

Fossils found in the Beaver Run Member include straight nautiloids, brachiopods, gastropods, corals, bryozoa, and conularids. Typically they occur in the middle part of the member. Occasional fossils and an asphalt-like hydrocarbon can be found in the upper part of the member. The hydrocarbon occurs both as small masses or clots and as an interstitial material between the dolomite euhedra.

The transitional zone, with the overlying Harmonyvale Member, is an alternating sequence of thin, coarse-grained beds, alternating chert beds, and dense, fine-grained beds.

Harmonyvale Member

The Harmonyvale Member is the highest of the Lower Ordovician rocks present in New Jersey. Its thickness (in excess of 220 feet) is determined by the amount of erosion on the unconformity. At many localities, the Harmonyvale has been completely removed and the Jacksonburg is deposited directly on the Beaver Run. This member consists of a dense, fine-grained to cryptocrystalline, conchoidal-fracturing, styolitic dolomite in one to five foot beds that weather to a light cream gray color. Some of these beds will make a ringing sound when struck with a hammer. There are many medium crystalline mottled, fetid beds that weather with a silty gray surface. Floating frosted quartz grains, sometimes rutilated, as well as chert beds up to several feet thick may be present. Some beds weather with a strongly dissected crosshatch surface, referred to as elephant hide rock (Hobson, 1963). This surface is due to solutional action on a myriad of closely spaced fractures. The fractures are filled with a siliceous material that weathers with thin raised ribs on the rock surface. Many sets of thin, wispy, carbonaceous, filled microfractures or seams occur in some beds.

A zone of grayish chert occurs about 50 to 60 feet above the base. Along strike this chert grades into four-feet thick lenticular limestone beds at the type locality near Harmonyvale. The limestone contains fossils. About 20 feet above the limestone is a very fine-grained bed containing peculiar structures composed of ovoid concentric rings up to eight inches in length. These structures, termed oncolites, are found in most Harmonyvale sections at about the same distance above the Beaver Run-Harmonyvale contact. Fossils in the Harmonyvale include gastropods, brachiopods, and trilobites as well as the oncolites.

The reasons for correlating the Beaver Run and Harmonyvale members to the Ontelaunee of Pennsylvania (Figure 1) are as follows: (1) The Big Springs Member of the Epler can be correlated with Hobson's "60 foot fossil zone" by similar fossils that have been found in the Big Springs limestone facies and by similar lithologies; (2) Hobson (1963) places his Epler-Ontelaunee contact at the highest limestone bed and approximately 100 feet below a massive chert zone. This chert section is probably equivalent to the middle part of the Beaver Run. Hobson states that the cherts are characterized by rugose or colloform chert; and (3) he

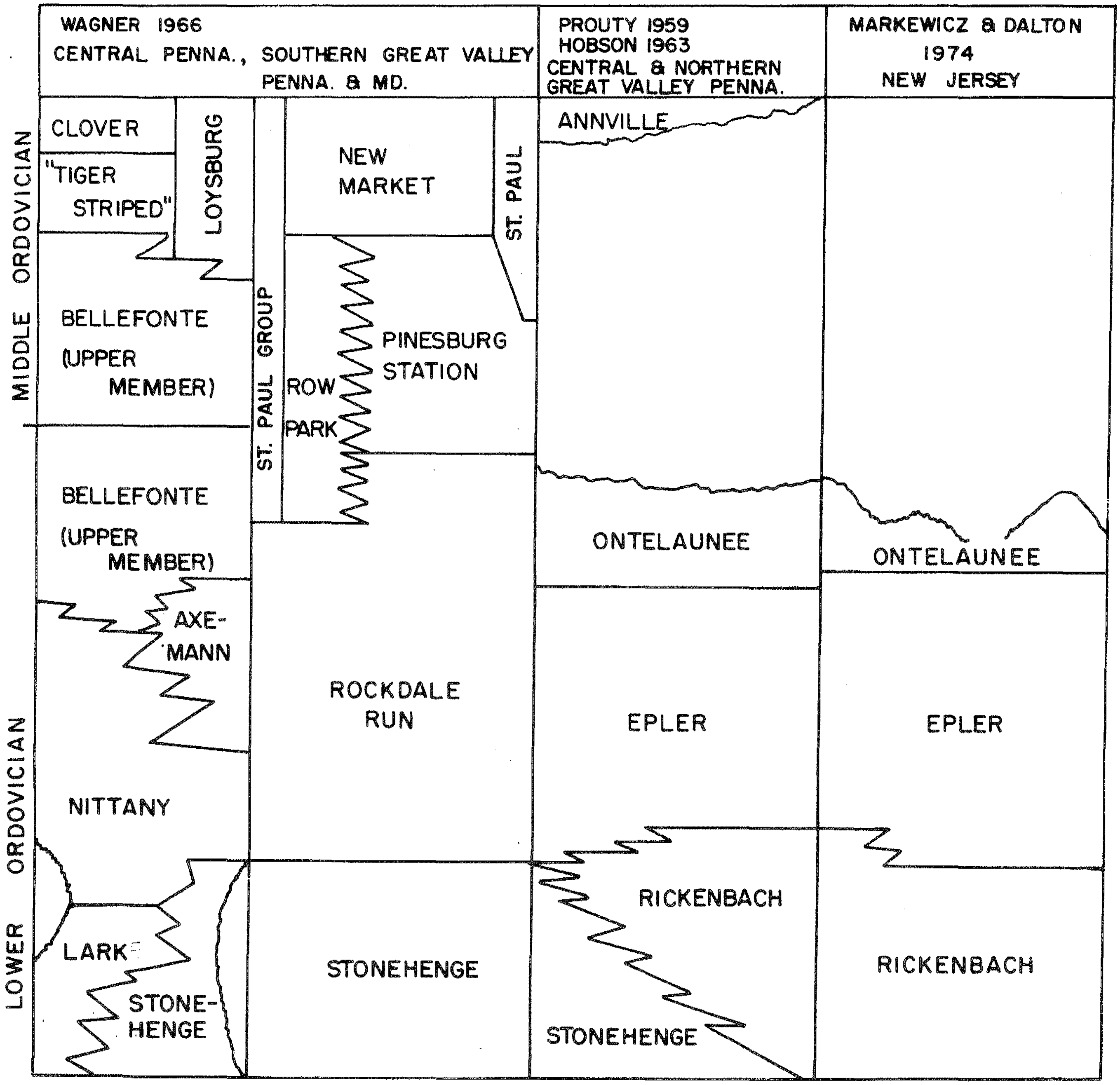


Fig. 1 Composite Correlation Chart

also states that nautiloids are *not* found in Epler. In the Beaver Run Member we have found many nautiloids, gastropods, and other fossils. In the Harmonyvale Member linguloid brachiopods, trilobites and gastropods have been found. The gastropods are similar to those seen high in the Ontelaunee of Pennsylvania by Markewicz. The base of the Ontelaunee, as we define it, does not coincide exactly with that of Hobson, since he places the contact at the change from limestone to dolomite and we place it at the change from the fine-grained laminated dolomites of Lafayette Member to the coarser-grained dolomites of Beaver Run Member. From the description of Hobson's measured sections, it appears that he includes a portion of what we call the Lafayette Member in the Ontelaunee.

Paleo-Solution Breccia

As mentioned under the description of the Lafayette Member, zones of paleo-solution breccia occur in the upper part of the "Kittatinny". These breccias have been interpreted as fault breccias by some workers and as intraformational conglomerates by others. Hobson (1963, p. 65) states that the massive breccia zones at Carpentersville are possibly fault related, although they do not look like fault breccias. They are commonly found in the Lafayette Member of the Epler Formation with similar breccias occurring in the Rickenbach and Ontelaunee as well. At some localities, the breccia has been traced from the lower part of the Beaver Run Member down through the Epler into the top of the Rickenbach, with a few short covered zones. The breccia may consist of angular blocks of laminated dolomite and rounded cobbles, very large slightly tilted blocks of laminated dolomite, or a zone of small fragments of slightly rotated laminated dolomite.

At some localities the breccia has filled tube-like channels in the rock. Generally, the breccia to wall rock contact shows no evidence of faulting. The clasts within the breccia, at many localities, consist of a heterogeneous assemblage derived from the overlying units as well as the unit containing the breccia. The interstitial material around the fragments is commonly a red to greenish silt, similar to the material found in present day karst deposits.

Some beds of dolomite contain a peculiar crackle breccia which consists of angular fragments measuring from one-quarter inch to greater than four inches in size, with the individual fragments showing little to no rotation. It is commonly found in a 50 to 200 feet thick zone, from the lower part of the Branchville Member of the Epler down into the Hope Member of the Rickenbach.

The crackling can disappear both vertically and horizontally in a few tens of feet. Within this zone of crackling, the breccia will be confined selectively to the dense, finely crystalline dark beds with little evidence of crackling in the coarser interbeds.

The filling material between the fragments typically consists of a white to light gray crystalline calcite and/or dolomite. In some areas such as Friedensville, Pennsylvania, the filling material is a light, honey colored sphalerite.

The crackle breccia is important because of its use as a possible ore (sphalerite) guide and, in some cases, for use in stratigraphic interpretation. At several localities in New Jersey, sphalerite has been found in association with the crackle breccia. Its similarity with the Friedensville crackle breccia is striking because it is difficult or impossible, even for the experienced geologist, to distinguish one from the other.

The origin of these breccias is related to the karstification of the upper portions of the Kittatinny during the erosional period prior to Jacksonburg deposition (the Knox-Beekmantown Unconformity). The relationship of the crackle breccia to the massive breccia (rubble breccia) is shown in Figure 2. The origin of the crackling is probably similar to the tension release fractures as found associated with present day cave passages.

The most important paleo-karst breccia occurrence is near Beaver Run, Sussex County. At this locality, 1.9 miles west of Route 94 on Beaver Run Road, a breccia body 300 to 400 feet wide can be traced downward for several hundred feet perpendicular to bedding. It is postulated that this breccia, before erosion, was more than 4,000 feet long. A few hundred feet to the south and higher on the hillside, one of the most unusual stratigraphic units present in the region is found. It occupies the interval between the Ontelaunee and Jacksonburg Formations (Fig. 3).

This unit consists of green siltstones with leached cavities and shards of chert, green siltstones, argillites, shales, and calcareous sandstones to pebble conglomerates. The green unit is about 200 feet thick and has a strike length of about 3,000 feet. It thins rapidly, both to the north and to the south, and is overlain by typical Jacksonburg. Based on the relationships observed at this locality, it is the opinion of the authors that the green unit fills a paleo-sinkhole. Figure 4 indicates the relationship between the development of the breccia and the downcutting during karstification.

The contact of the green unit with the dolomite was dug out at this locality. A very dark, manganese-rich, soft, earthy, soil-like zone occurs at the contact. The top of the Harmonyvale is irregular and the beds are parted

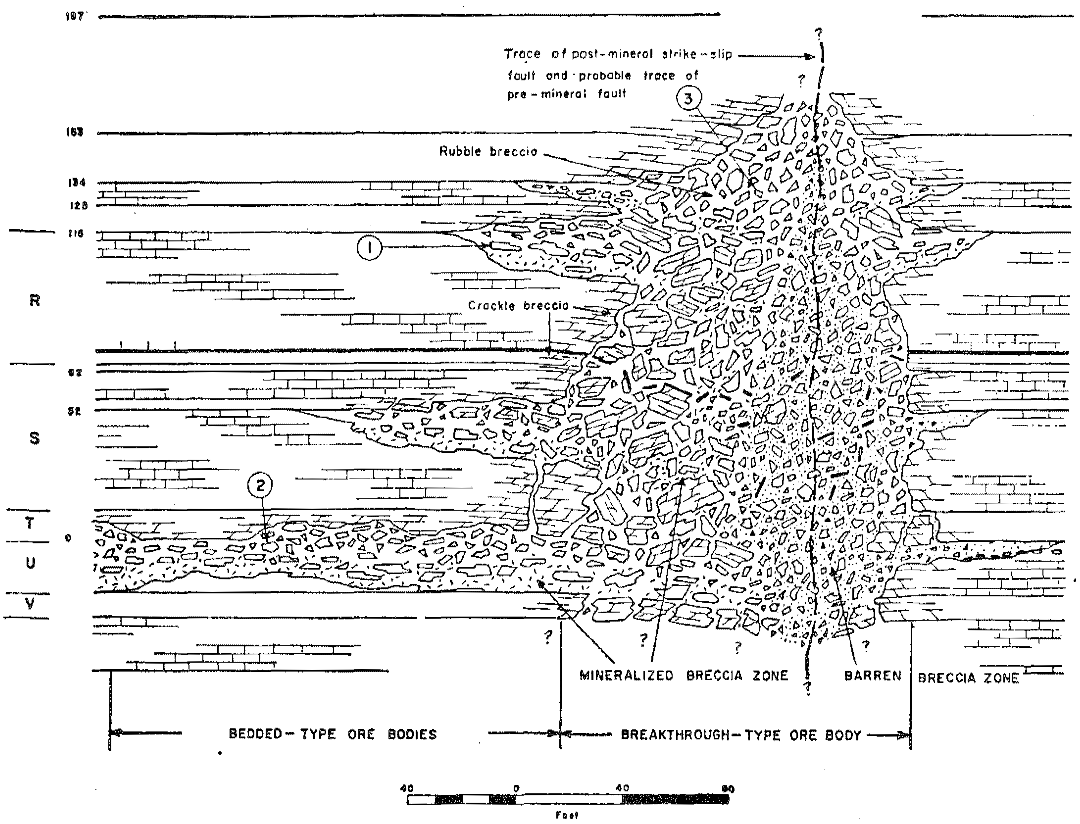


Fig. 2 Relationship between crackle breccia and rubble breccia (Fig. 4, Hardeman and others, 1969)

by a thin quartz-dolomite filled fracture system. Many of the filled fractures show a definite curving pattern with the top of the fractures bending in the same direction that the bedding is sagging, toward the center of the sinkhole.

This green unit has been found at several other localities. At one, near Swartzwood Lake, beds of massive conglomerate are interbedded with greenish argillaceous beds for a stratigraphic thickness of greater than 85 feet. The conglomerate beds are up to 25 feet thick with the intervening argillaceous beds up to 10 feet thick. This "pre" Jacksonburg unit represents the filling of some of the sinkholes developed on the paleokarst surface with the residual soil and rock fragments.

A similar unit known as the Dot Formation occurs at the top of the Knox unconformity in Tennessee. The following description is from Hardeman and others (1969, p. 41):

> "The basal facies of the Dot Formation is a series of argillaceous conglomerate, limestone, and shale units that fill irregularities on the Knox erosion surface. At the mine the basal beds of the Dot can be subdivided into four lithologic units (fig. 1). The lower unit (Ods) is greenish-gray shale with interbeds of argillaceous dolomitic limestone that contains abundant small chert fragments. This is directly overlain by a thin zone of lutite-textured grayish limestone (Odll). These units are present in the western part of the map area but pinch out against the unconformity in the central part of the mine (fig.1). Overlying the lower limestone (Odll) unit is a massively bedded, yellow-weathering argillite (Oda) which contains abundant angular chert and dolomite clasts as much as three inches in diameter. This unit is succeeded by massively bedded, bluish-gray limestone which contains very thin discontinuous lentils of fine-crystalline dolomite (Odul)."

The green unit is unique, not only because of its stratigraphic position and lithology, but also its relationship with major paleosolution breccia bodies for use as a guide in sulfide exploration.

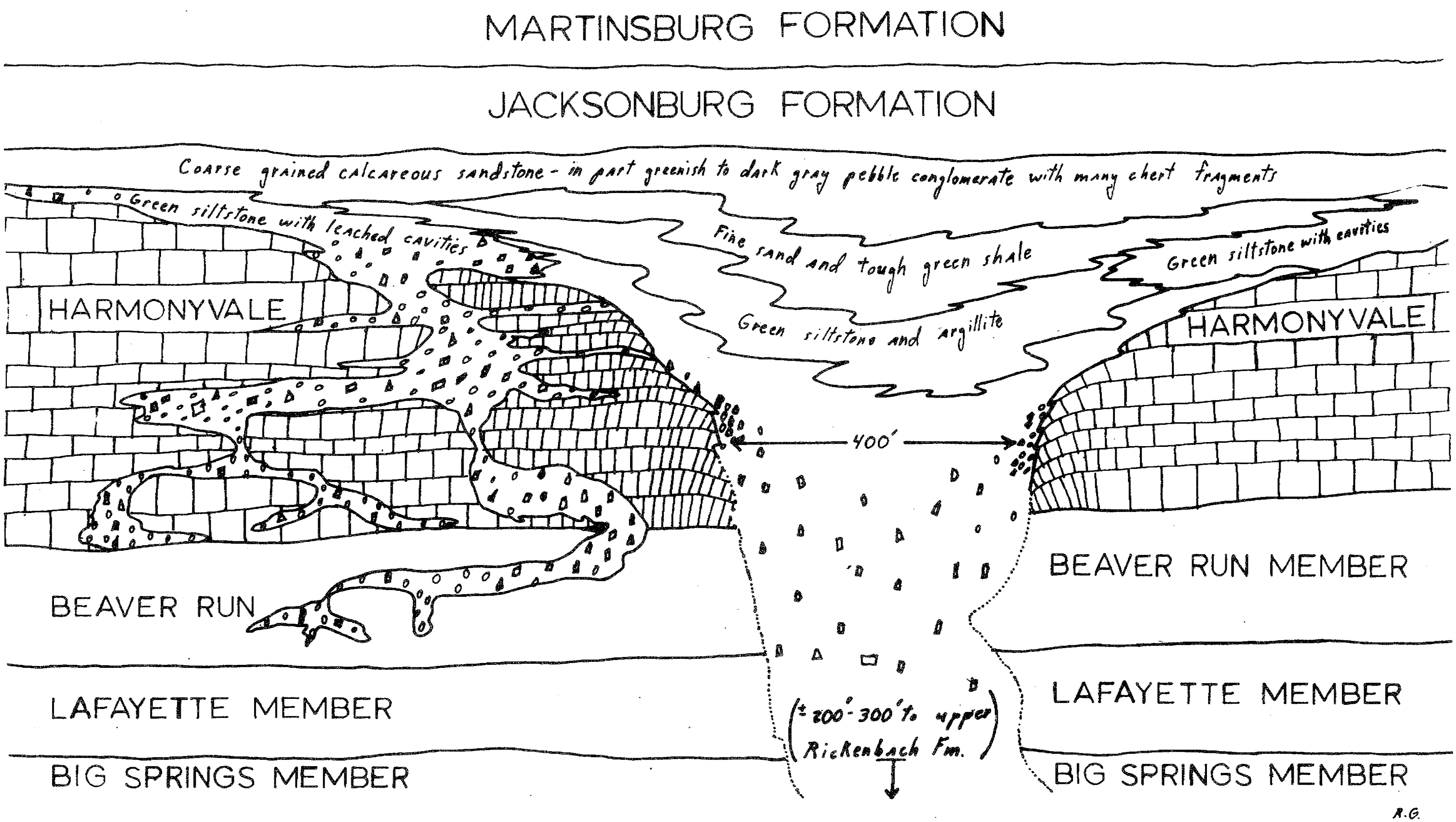
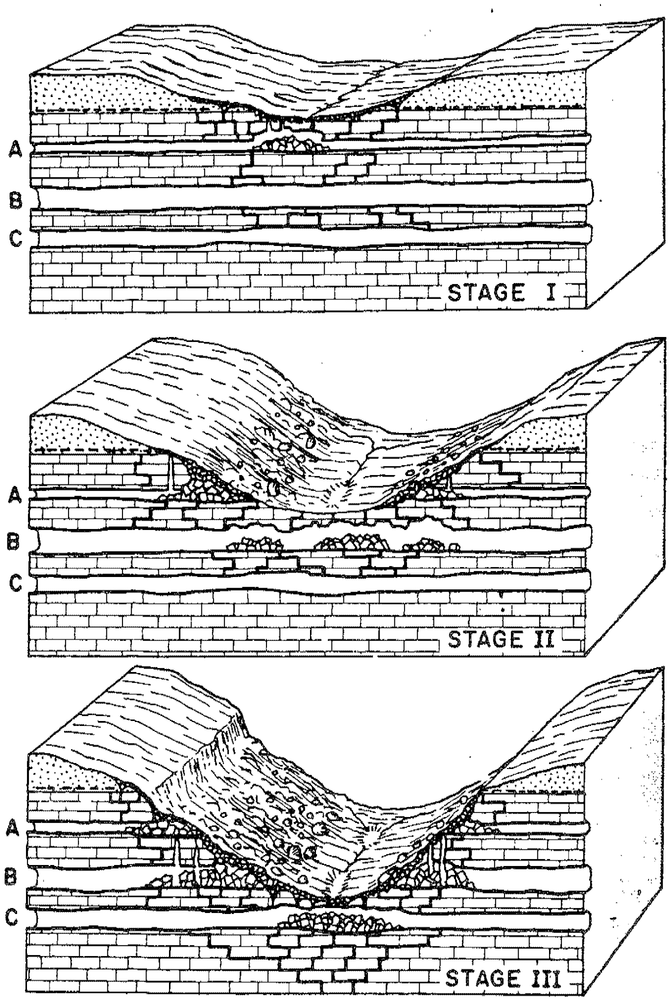


Fig. 3 Generalized Section of Paleosolution System South of Hamburg



Stages in cave passage truncation.

Fig. 4 Relationship between the downcutting during karstification and development of breccias (breakdown) (Fig. 2, Bruckner, 1966)

JACKSONBURG FORMATION

The Jacksonburg Formation was first named by Kummel (in Spencer and others, 1908) for the exposures at Jacksonburg, New Jersey. A systematic examination of the type section was done by Weller (1903). A trench was started at the Kittatinny-Jacksonburg contact and excavated uphill almost to the Martinsburg contact, a thickness of more than 122 feet.

The Jacksonburg was divided into a "cement rock" (upper) and the "cement limestone" (lower), by Kummel (1901). Prouty (1959) postulated a tentative correlation with the Hershey and Myerstown of central eastern Pennsylvania, with the "cement rock" and "cement limestone" in eastern Pennsylvania. It is likely that this correlation is valid for New Jersey.

The lower contact between the "cement limestone" with the "Kittatinny" is a pronounced karst unconformity. At the Sarpeta Quarry locality, the Jacksonburg has been deposited in a trough eroded at least 300 feet into the Ontelaunee Formation with the bottom of the trough not being exposed.

The "cement limestone" is medium to dark gray, fine to coarsely crystalline limestone which locally is a high calcium limestone. There are some light to medium gray calcarenite beds. At many localities, the basal part of the formation contains thin to thick beds of conglomerate. One of the thickest conglomerate sections is along Route 80 near Hope, where 275 ± feet of conglomerate has been measured. It is now possible, with the dolomite member subdivision, to recognize many of the individual cobbles in the conglomerate. The "cement limestone" has been estimated to be about 200 to 300 feet thick, Kummel (1900) and Drake (1969).

The "cement rock" consists of a dark gray to black, argillaceous limestone that has a pronounced cleavage. It contains some beds of coarsely crystalline limestone. Kummel (1900) and Drake (1969) estimate the "cement rock" to be in excess of 600 feet thick at some localities.

ROAD LOG

Mileage

0.0 Start at Rutgers-Newark assembly point. Proceed west via Interstate Routes 280 and 80 toward Allamuchy.

25.2 Intersection of Interstate Route 80 with State Route 15. Note: Precambrian rock cuts along Route 80. There will be some "on-bus" discussion of these igneous and metasedimentary rock units.

33.2 Intersection of Interstate Route 80 with Route 46 Exit ramp.

33.7 Mile marker 26 on Route 80

38.7 Entrance to scenic view of Delaware Water Gap

42.5 **STOP 1**

Geologic Setting

Limeport member of the Allentown Formation. Although less than 20 feet is exposed here it contains many of the sedimentary features found in the member.

In the Pequest Valley the highest stratigraphic rocks found by Markewicz and Dalton include units from Leithsville through the middle part of the Upper Allentown. Stop 1 is considered to be in the lower half of the Limeport Member.

The southeastern edge of the valley is underlain by a normal section of "Kittatinny" sediments lying above the Precambrian.

Along the southwestern border of the valley there are complex structural relationships just before the point where Route 80 enters the Jenny Jump Mountain Precambrian units. There have been various interpretations for this contact between the Precambrian and Paleozoic. These include nappe theories, normal contacts, and various fault interpretations such as an unrooted thrust block.

The Leithsville and Lower Allentown (Limeport) typically form a topographic lowland on the eastern border of the valleys in northern New Jersey. Leithsville rocks generally underlie the lowlands or river valleys and have a greater thickness of unconsolidated sediments - sand, gravel, clay, etc. overlying bedrock than any of the other formations of the "Kittatinny group." The Limeport, typically more resistant than the Leithsville forms a slighty higher pronounced bench. It is generally overlain by overburden that is thinner than the underlying Leithsville overburden, but thicker than overburden Upper Allentown.

Geologic Features

(a) algal units

(b) oolitic and local pisolitic units

(c) churned, lumpy, patchy bioturbidite facies

(d) intraformational conglomerate facies

(e) sandy facies

(f) ruditic, patchy textured clast conglomerate

(g) various dolomite facies, from dolomitic mudstones to medium coarse crystalline dolomite grainstone.

Many varied shallow water carbonate environments can be found at this stop. This is the type of outcrop that a geology professor likes to take his students to so that they can observe the many features that they hear about in the classroom.

44.6 Continue west on Route 80. Diabase dike within metasedimentary calc-silicates and various gneisses.

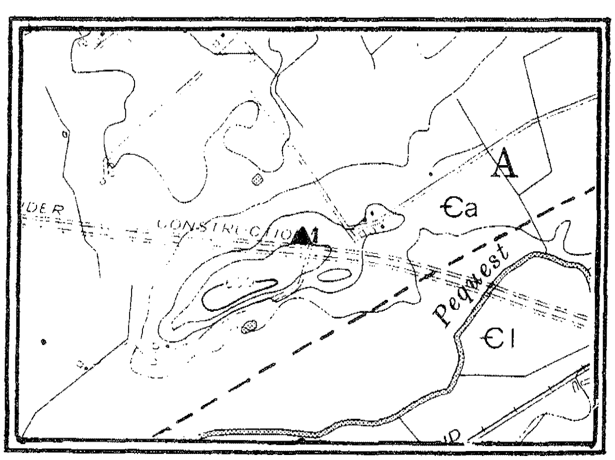


Fig. 5 Topography based on tranquility 7½ — quadrangle. (Geology by Markewicz and Dalton)

Legend [for fig. 5, 6, 7 & 8]

- Δ Stop
- Omb Martinsburg Formation
- Ojb Jacksonburg Formation
- Oo Ontelaunee Formation
- Oe Epler Formation
- Or Rickenbach Formation
- Ꞓa Allentown Formation
- Ꞓl Leithsville Formation
- Pe Precambrian

45.5 **STOP 2**

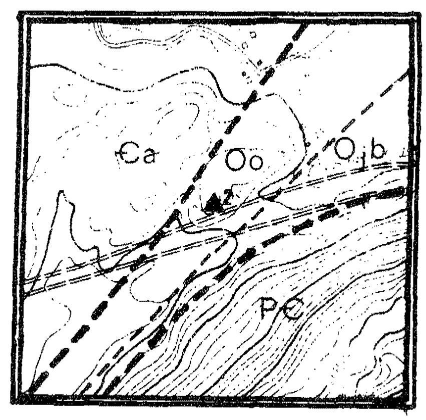


Fig. 6 Topography Blairstown 7½ — minute quadrangle. (Geology by Markewicz and Dalton)

Geologic Setting

Harmonyvale Member of the Ontelaunee Formation

This is the first exposure of dolomite on the west side of Jenny Jump Mountain.

During the construction of Rt. 80 the Jacksonburg Limestone was exposed at the east end of the exposure. On the west side of Jenny Jump, the first rock exposed is always the Jacksonburg along with the uppermost part of the Kittatinny sequence.

At Stop 2 exposures of the uppermost-lower Ordovician dolomite present in New Jersey can be observed; this is the Harmonyvale member of the Ontelaunee Formation.

Geologic Features

(a) dark to black wispy lines or streaks

(b) medium crystalline fetid beds

(c) massive paleo-solution breccia with silt (paleokast feature)

(d) possible fossils

(e) recent karst features

Black wispy lines are an important feature to be noted here. These seem to have been formed through some deformation process shortly after deposition of the dolomite since the Jacksonburg conglomerates in this region contain dolomite cobbles which have the wispy lines.

46.2 Exposures of the upper part of the Allentown Formation

46.8 **STOP 3**

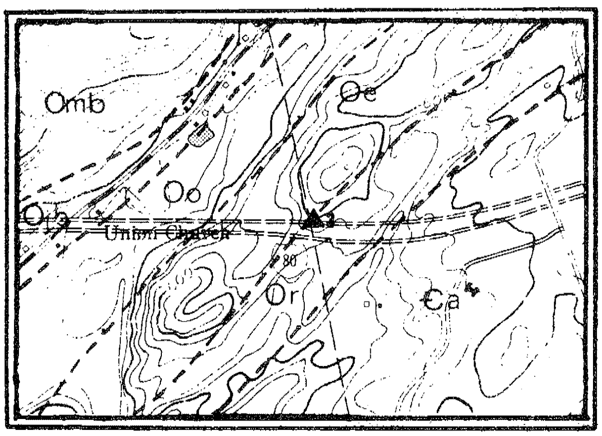


Fig. 7 Topography based on Blairstown 7½ — minute quadrangle. (Geology by Markewicz and Dalton

Geologic Setting

The Rickenbach and Epler Formations

This series of exposures which starts in the upper Allentown Formation and extends up to the Lafayette Member of the Epler forms one of the most complete sections in this area. Off the road, the section continues up into the Jacksonburg Limestone. We will be limiting discussion to the Rickenbach and Epler Formations at this stop.

A. The Rickenbach Formation at this locality measures approximately 290 feet and both the lower and the Hope Members are present. This stop is also the type section for the Hope Member. The features to note are:

a) compare lithologies of the lower member with the Hope Member.

b) clots of black botryoidal hydrocarbon? material -anthrazalite?

c) sand in the dark aphanitic beds

d) the "7 cherts" horizon

e) the upper chert horizon

f) algal structures

g) Trace amounts of sphalerite occur over a stratigraphic thickness of 225 feet.

B. The Epler at this stop has complete sections of the Branchville and Big Springs Members and a partial section of Lafayette Member. The features to note in the Epler are:

a) compare the alternating medium to massive bedded sequence of the Hope Member of the Rickenbach with very massive bedded laminated dolomites of the Branchville Member of the Epler.

b) the similarity of the Branchville with the Lafayette Member

c) note the siliceous ribbing (interbeds) as well as the distinctive reddish weathering characteristic of the dolomite.

d) the paleo-solution breccia in the Lafayette Member

e) fossils found in the Big Springs Member.

48.1 Route 521 exit ramp

50.1 **STOP 4**

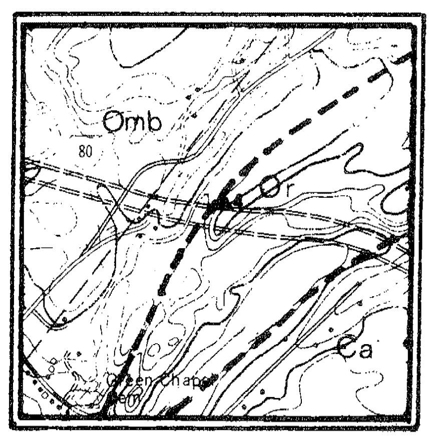


Fig. 8 Topography based on Blairstown 7½ — minute quadrangle. (Geology by Markewicz and Dalton)

Geologic Setting

Rickenbach Formation

From Stop 3 the highway cuts across the Jacksonburg and the Martinsburg Formations west of Route 521. As the highway ascends the large hill known as Mt. Herman a west dipping thrust fault is crossed. The first dolomite exposure is the Limeport Member of the Allentown Formation.

The west side of Mt. Herman is also bounded by a fault. This fault, based upon preliminary mapping is high angle.

Geologic Features

a) the changes in dip

b) the large amount of sulphides present in the rock

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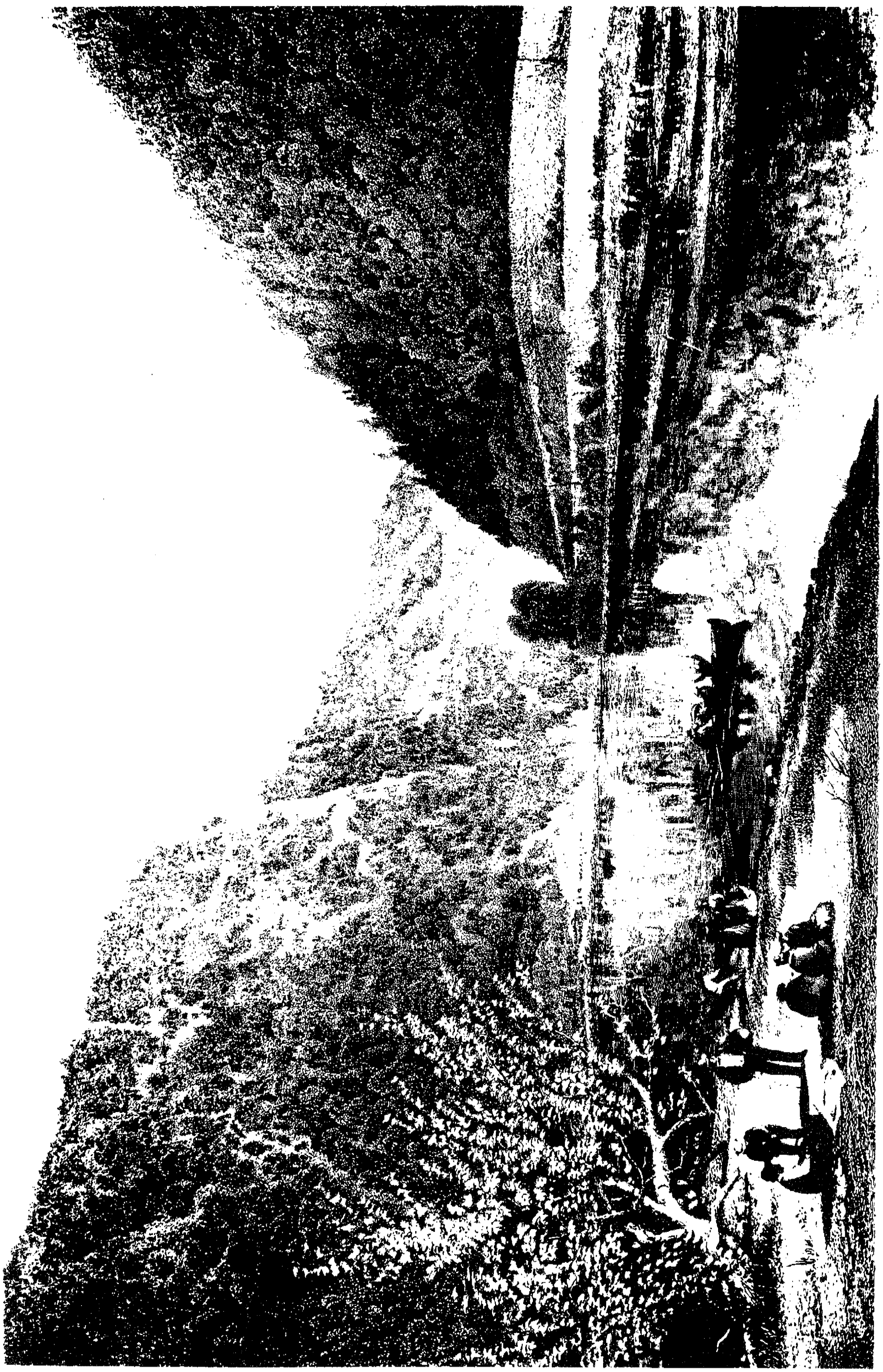

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