CHAPTER 7.

CHESTER GROUP

Name and Limits. The Gasper oolite was named by Butts[36] in 1917, from Gasper River, in the western part of Warren County, Ky. The lower boundary of the Gasper has been already described in connection with the Ste. Genevieve limestone. Strictly speaking, if the shaly layer above the Ohara member is the equivalent of the Bethel sandstone, as surmised, the bottom of the Gasper is at its top. In practice, however, the top of the Ohara member is taken as the bottom of the Gasper. In the western belt of outcrop, in Meade and Breckinridge counties, and perhaps farther south, the Gasper, owing to the absence of the Ohara, rests upon some lower part of the Ste. Genevieve. In an old quarry at Richardson's landing, in Meade County, the Gasper rests on layers of white limestone with *Lithostrotion harmodites.* These *Lithostrotion* bearing layers are certainly below the horizon of the Rosiclare sandstone member, and so in the Fredonia oolite, the entire Ohara being absent. Here there is an unconformity at the base of the Gasper measured by the Ohara limestone member and Bethel sandstone, amounting to 200 feet. In the type locality of the Gasper, however, in the western part of Warren County the Ohara is believed to be present, and consists of about 40 feet of thick-bedded limestone. Along the entire western belt of outcrop between Meade and Warren counties the Gasper is bounded above by the Cypress sandstone, and the Cypress forms the upper boundary probably in Clinton County and in the southern part of Wayne County but in most of Wayne County and north to Carter County the top of the Gasper is supposed to be a few feet below a persistent green, marly shale bed, in Kentucky about 10 feet thick. The shale is certainly the same as a shale above the Cypress sandstone in Overton County, Tenn., regarded as representing the Golconda formation of western Kentucky. (See Sec. No. 1 of section chart.) A few feet of limestone included in the top of the Gasper is also regarded as Gol-

[36] Butts, Charles, Mississippian formations in Western Kentucky, Part I, page 64, 1917.

conda, the Cypress sandstone horizon being believed to lie below this limestone and about 10 feet below the persistent shale bed. The position of this shale is everywhere marked on the slopes by a narrow but perfectly distinct and easily recognized terrace, along which in Tennessee roads and paths are located in many places. For all practical purposes this terrace may be taken to mark the top of the Gasper in eastern Kentucky. Evidences of the shale in the form of green or red clay is usually obvious on this terrace or can be detected by a short search.

Distribution. The Gasper oolite outcrops continuously along both the east and west sides of the Bluegrass region but the two belts are nowhere connected, although the Gasper is present in the knobs across Hart County and in Green River Knob in the south corner of Casey County. It probably is not present in Green, Taylor, Adair, Metcalfe, Allen, Monroe, or Cumberland counties, although there may be some knobs high enough to catch it in the southeastern part of Cumberland County. The eastern belt extends along the western escarpment of the Kentucky coal fields in Kentucky and of the Cumberland Plateau in middle Tennessee into Alabama. The western belt is continuous from Ohio River in western Meade County, through the intermediate counties to central Warren County. It makes the face of the escarpment or bluff about 2 to 5 miles northwest of the Louisville & Nashville Railroad and visible therefrom all the way from Munfordville to Bowling Green. Along its eastern outcrop it is the principal component of the limestone cliff so conspicuous from Rockcastle county to Powell county near the top of the escarpment bounding the coalfield. (See photos, Plates 22, 64 and 65.) The Gasper continues north into Ohio but does not extend as far west in Carter County as docs the underlying Ste. Genevieve. The Gasper extends beneath the eastern Kentucky coal field as a part of the Big Lime, and reappears at Pineville and Cumberland Gap, where it makes up about the upper half of the lower half of the Newman limestone.

Character. As indicated in the name, the Gasper is mostly an oolitic, somewhat crinoidal limestone, but has a little shale. In general it does not differ in any important lithologic character from the underlying Ste. Genevieve limestone or oolite,

except possibly in its tendency to develop yellow layers in places, as in the vicinity of Mt. Vernon, Rockcastle County and of Carter, Carter County. A good general notion of its character can be had from an inspection of the written section of Sparks quarry, near Mt. Vernon, in the description of the Ste. Genevieve, pp. 140-141, also in the Gasper section of the same quarry, No. 5, Plate 69, and other sections as Nos. 5, 12, 13, 19, 23, 38 and 41 of the general section chart.

The Gasper is nearly all thick bedded throughout its extent and light gray or bluish gray. At Olive Hill and Carter, Carter County, as shown in the quarries at those places, however, it is largely made up of massive layers of yellow oolitic limestone. Even here it has conspicuous layers of light gray oolite. (See Plates 74 and 75.) A notable feature of the Gasper is an apparently universally persistent thick bed of light gray oolite in the lower part that is of the character and occupies the position of the "Bowling Green oolite," a high-class building stone in Warren County. This bed is No. 12 of the written section, p. 141, and is well-shown in the photograph of Sparks quarry, Plate 67. Plate 77 is a photograph showing the general appearance of the Gasper in its western outcrop.

Economic Uses. The Gasper oolite probably is of as good quality as the Ste. Genevieve, and would be equally suitable for lime and cement manufacture. At Olive Hill, Carter County, it is reported to include layers averaging 98 per cent. of calcium carbonate. It is not at present utilized for such purposes but is quarried in the vicinity of Mt. Vernon, Rockcastle County, and Olive Hill and Carter, Carter County, far ballast and road metal.

Thickness. Along its western outcrop the Gasper is about 100 feet thick. On the eastern outcrop it is thickest in the south and thins gradually northward. At Monticello, Wayne County, it is 134 feet thick, at Mt. Vernon, Rockcastle County, it is 95 feet thick; at Irvine 50 feet thick, on Morris Mountain, Powell County, about 40 feet thick, at Olive Hill about 45 feet, and at Carter, Carter County, 27 to 30 feet. Where the Sample sandstone member reaches its greatest thickness, in Breckinridge county, the Gasper is 140 feet thick.

Sample Sandstone Member. In Breckinridge and Meade counties a sandstone of variable thickness occupies the middle of the Gasper. It was named by Butts[37] in 1917 from Sample, Breckinridge County, a small station on the Louisville, Henderson and St. Louis Railroad.

The Sample sandstone is a rather prominent member throughout Breckinridge County, where its horizon has escaped erosion. It varies greatly in thickness in short distances, in places being thin and shaly and less than one mile away being a massive sandstone 40 feet thick. It thins southward and near Eastview, on the Illinois Central Railroad, is represented by about 20 feet of shale with thin sandstone layers in the middle. Southwestward and westward to Caldwell County the Sample member is represented by a persistent clay up to 5 feet thick in the midst of the Gasper. The horizon of the Sample sandstone member is not indicated in the Gasper east of the Bluegrass region.

Fossils and Correlation. The Gasper in eastern Kentucky does not yield many fossils either of individuals or species. It does, however, carry some highly distinctive forms which are believed to be confined to it. A list is given below for both the eastern and western areas:

LIST NO. 39.

Partial List of Fossils from the Gasper Oolite of Eastern and Central Kentucky.

Campophyllum gasperense n. sp. Butts, branching coral.
Large crinoid stem up to nearly 1 inch in diameter not known in any other Chester formation.
Pentremites godoni De France.
Pentremites planus Ulrich.
Pentremites pyriformis Say. Most common and persistent fossil of the Gasper.
Pentremites symmetricus Hall.
Pentremites welleri Ulrich.
Agassizocrinus sp.?
Talarocrinus delicatulus Ulrich.
Talarocrinus elegans Lyon and Casseday.
Talarocrinus ovatus Worthen.

[37] Butts, Charles, The Mississippian formations of western Kentucky. Kentucky Geol. Survey, p. 70, 1917.

Talarocrinus patei Miller and Gurley.
Talarocrinus sexlobatus (Shumard).
Talarocrinus symmetricus Lyon and Casseday.
Archimedes laxus Hall.
Archimedes terebriformis Ulrich.
Archimedes swallowanus Ulrich?
Chonetes chesterensis Weller.
Diaphragmus elegans (Shumard).
Diaphragmus monte sana Ulrich?
Girtyella indianensis (Girty).
Martinia contracta Meek and Worthen.
Productus inflatus McChesney.
Productus ovatus Hall.
Spirifer leidyi Hall.
Bellerophon sublaevis Hall?

The forms important for correlation in this list are the big crinoid stems, the branching coral, and the species of *Pentremites, Talarocrinus,* and the *Martinia.* The listed species of all these genera are all or nearly all present in the type locality of the Gasper. The species of *Talarocrinus* named do not occur outside of the Gasper. Indeed the genus does not appear to range above the Gasper, no instance of its occurrence above being on record so far as the writer is aware. All the species of *Talarocrnus* listed occur on the eastern outcrop of the Gasper, some of them at least as far north as Kentucky River, and a single base of an apparently different species was obtained from the quarry at Olive Hill, Carter County. Species of *Talarocrinus* occur at Big Stone Gap, Va., in oolite somewhat below the middle of the Newman limestone. The *Pentremites,* especially the species *godoni, planus* and *pyriformis,* are equally characteristic of the Gasper in both of its areas of outcrop. The first two named species are absent or scarce north of Somerset, but *Pentremites pyriformis* is persistent and fairly plentiful throughout the entire extent of the Gasper, even into southwestern Virginia. It is rather plentiful at Carter, Carter County, in association with *Martinia contracta,* and is recorded from the Maxville limestone of Ohio. *Campophyllum gasperense* is another charasteristic fossil of the lower part of the Gasper. It is reported by Ulrich from Caldwell county, Ky., is present in the northwestern part of Warren County, the type locality of the

Gasper, at Smiths Grove, Warren County, and at Sample, Breckinridge County. It occurs in myriads near Cowan, Franklin County, Tenn., in association with the Gasper Pentremites, and has been collected along the eastern belt of the Gasper, as far north as Somerset, Ky., invariably within 20 to 30 feet of the bottom of the Gasper. It is common at the north end of Lookout Mt., Tenn. and at Big Stone Gap, Va. where its horizon is also about 30 feet above the bottom of the Gasper. This species is described below. The big crinoid stems are also invariably present in the upper part of the Gasper from Overton county, Tenn., to Carter, Carter county, Ky. Its general position is about 20 to 30 feet below the top.

The stratigraphic relations, lithologic character, and fossils prove beyond a doubt the identity of the Gasper throughout eastern Kentucky, and carry it into Ohio as the main fossiliferous part of the Maxville limestone, as concluded by Ulrich in 1917.[38]

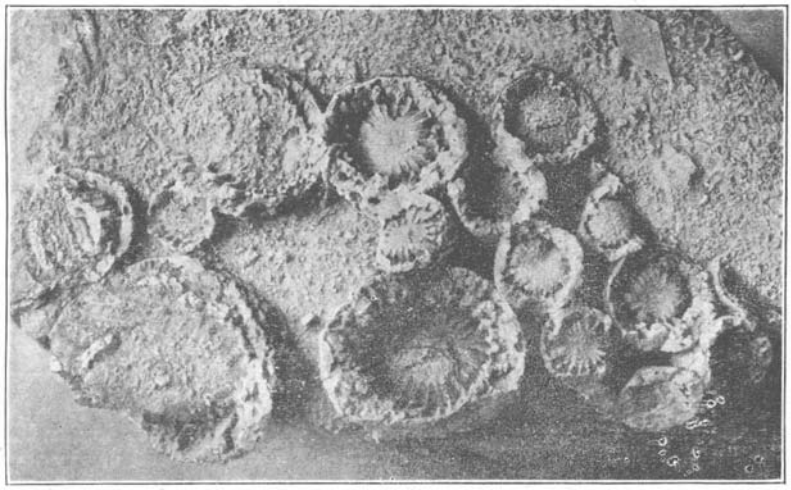
CAMPOPHYLLUM GASPERENSE n. sp. Butts. Plates 78 A-D. Also p. 136 figs. 2-3, and p. 156 figs. 4-6.

Corrallum composite, coralites cylindrical, slightly tapering. In contact tangentially or free, generally the former. Epitheca wrinkled. Increase mainly by calycinal gemmation, as many as a dozen coralites being given off at one circlet.

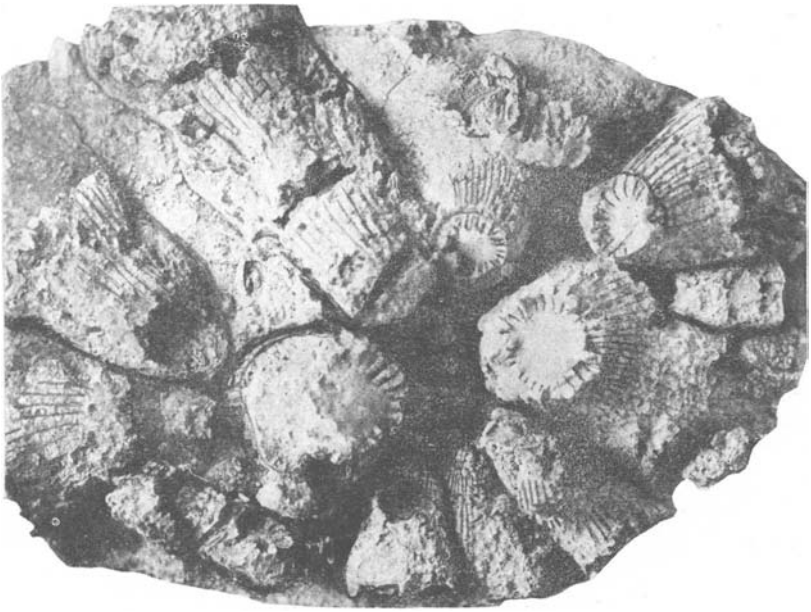
The largest specimen observed is 32 millimeters in diameter at the top of the calice. A specimen about 50 mm. long is 12 mm. in diameter at the distal end which would indicate a length of 150 mm. for the largest specimen. Calice deep. In a specimen 15 mm. in diameter it is 10mm. deep with perpendicular inner wall nearly to the bottom where the septae begin to widen and curve inward. Bottom of the calice flat with the septae extending inward as low, sharp crests for a distance equal to about 1-3 of the diameter. The central 1-3 of the bottom is perfectly flat and smooth.

Tabulae horizontal, deflected downward around the margins between the septae and the theca, about 1 mm. apart. A polished specimen 21 mm. long has 21 tabulae somewhat unevenly spaced.

[38] Op. cit



78-A. Campophyllum gasperense. N. sp. natural size cluster of coralites. Top view. Usual appearance in the limestone.



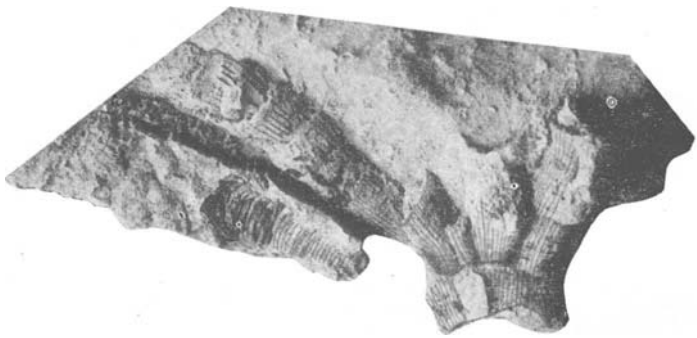
78-B. Reverse of 78-A, showing manner of growth from a central stock. Gasper oolite, McFadden Creek, 7 miles northwest of Bowling Green, Ky.

Septae alternating, wide and narrow, the primary ones extending inward about 1-6 the diameter nearly down to the bottom where they extend inward as far again as low, sharp crests on the surface of the tabulae. The secondary septae obsolete or obliterated in silicification in most of the silicified specimens. A specimen 23 mm. in diameter has 36 primary and as many secondary septae, another specimen 32 mm. in diameter has 48 each primary and secondary septae.

The septae are all smooth on the edges and sides.

The counter and alar septae are not distinguished from the others. The cardinal septum, situated in a narrow, oblong fossula, is narrower than the others. The fossula extends inward 1-3 the diameter or to the inner edge of the ring of septae.

The extrathecal zone of interseptal vesicular tissue is about 1-6 the diameter of the interthecal space. The interseptal vesicular plates are ascending and slope outward to the epitheca.



78-C. Campopllyllum gasperense. N. sp. X-l½. Reverse of specimen shown in 78-D 2. Showing part of a circlet of coralites arising by budding.

The individual colonies of this species reach large size. A mass has been observed about 2 1-2 x 1 1-2 x 1 foot in dimensions with coralites projecting from the surface all around.

From its compound habit this species could easily be mistaken for *Lithostrotion proliferum* especially from the exposed ends of the coralites on a weathered surface of limestone.

Horizon and Locality. Lower part of the Gasper oolite in which it is distributed throughout Kentucky, Tennessee, Virginia and Alabama as described above.

78-D. Campophyllum gasperense. Cluster of coralites partly arising by budding from a single coralite at base of specimen. Reverse is shown in 78-C. Lower part of Gasper oolite, Cowan, Tenn.

CYPRESS SANDSTONE

Name. The name Cypress was given to the sandstone here under consideration by Englemann[39] in 1866. The name is from Cypress Creek, in Union County, Ill., where the sandstone is exposed in bluffs and cliffs. In Kentucky the sandstone was later called the "Big Clifty sandstone" by Norwood[40] in 1876. By the law of priority Cypress is the name that should prevail. The Cypress follows the Gasper, wherever exposures have permitted observations, without any evidence of unconformity. (See Plate 79.)

Distribution. The Cypress sandstone in Kentucky is mainly confined to the country west of the meridian of Louisville

[39] Englemann, Henry, "Report On Hardin County, Ill. Illinois Geol. Survey, Vol. 1, p. 356. 1866 .
[40] Norwood, C. J., Geol. Survey of Kentucky, New Series, Vol. 1, 1876.

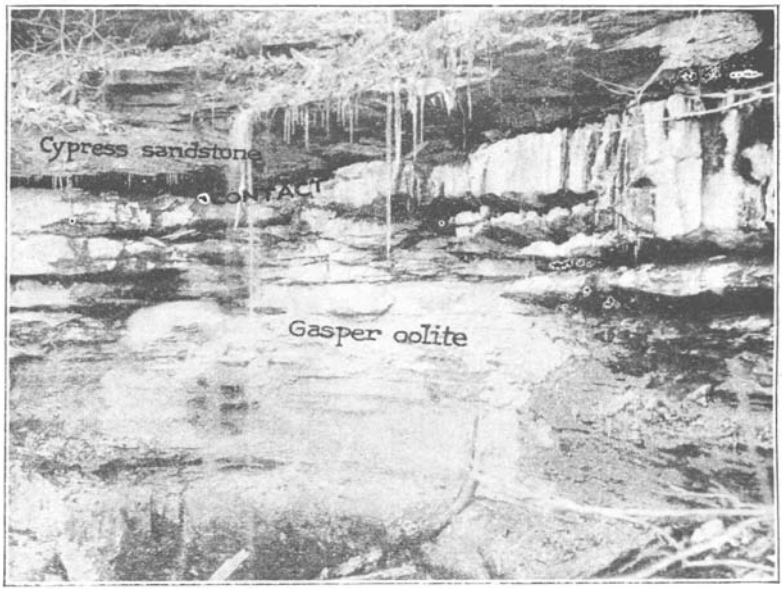


Plate 79. View showing the contact of the Cypress sandstone and Gasper oolite. Ravine about 1 mile south of Livingston, Tenn. Looking south. No indications of erosion previous to the deposition of the Cypress here or at many other points in Overton County where this contact is exposed.

and north of the latitude or Bowling Green. It caps the bluff visible on the west and north from the Louisville and Nashville Railroad much of the distance from Munfordville, Hart County, to Russellville in Logan County. It also caps a number of knobs lying to the south and east of the bluff, such as Pruits knob south of Cave City and the conspicuous buttelike knob south of Munfordville. (See Plate 80.) It is the sandstone forming the surface above the entrance of Mammoth Cave. It caps the high hills clear across Hart County. It is not present, however, in Green River Knob, in the south corner of Casey County, the sandstone capping that knob being Pottsville or "Coal Measures" sandstone. In the eastern outcrop of the upper Mississippian formations the Cypress sandstone is not present at Monticello nor north thereof to Ohio River. A section at Parmleysville, 12 miles southeast of Monticello, pub-

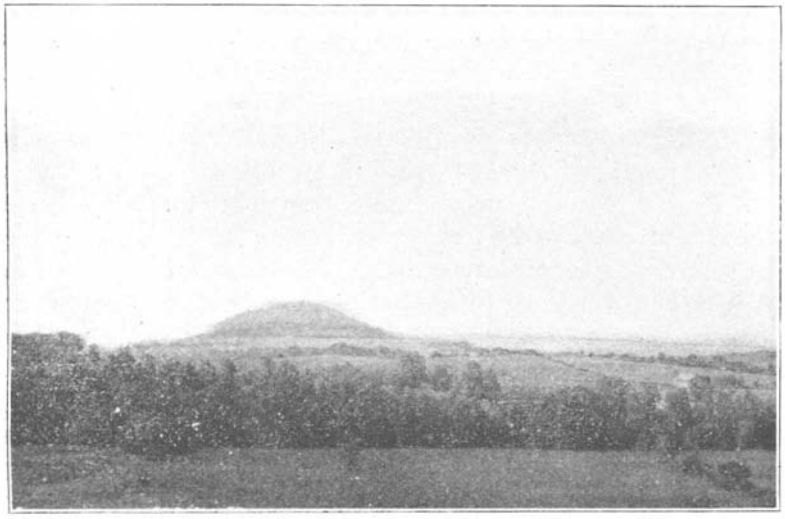


Plate 80. Knob or butte capped with Cypress sandstone. About 2 miles southwest of Munfordville, Hart County. Looking southwest. Slopes of Gasper and Ste. Genevieve (Fredonia) oolites, mainly the first named. This is an outlier from the main body of these formations, the east-facing escarpment of which is capped by the same sandstone and is shown in the distance.

lished by Munn[41], shows 10 feet of "thin-bedded, impure, curly ripple-marked fossiliferous" sandstone in limestone that may represent the Cypress, but it is not certain that it does. In the northeast corner of the Standingstone quadrangle, Tenn., in the northwestern corner of Fentress County, the Cypress is present and variable in thickness. At some points it is absent altogether, at others very thin (6 inches to a foot) of shaly calcareous sandstone, and at other points a thick-bedded sandstone 40 feet thick. It is particularly well developed in the northwestern one-fourth of the Standingstone quadrangle, in the vicinity of Livingston and to the northwest thereof.

Character. The Cypress sandstone is usually a thick-bedded to massively bedded sandstone, gray in color or somewhat iron stained in places. In the vicinity of Eastview station, in Hardin County, a part of the Cypress is massive and friable, weathering down into a clean white sand. In places, too, it is thin bedded and has strongly cross-bedded layers as in the locality

[41] Munn, M. J., U. S. Geol. Survey Bull. 579, p. 31, 1914.

of the photograph, Plate 79. In the vicinity of Sample and Stephensport, Breckinridge County, it takes on a shale facies and has very little sandstone. Some of the shale is red, but most of it is green.

Thickness. The Cypress sandstone from Breckinridge County south to Warren County varies from 50 to 80 feet thick. In Overton County, Tenn., it is in most of the areas where it is present about 40 feet thick. It is thinnest in eastern Overton and western Fentress counties, in the region nearest to Kentucky, so that its thin development or practical disappearance in Clinton County and southern Wayne County is in harmony with the condition and behavior a few miles to the south in Tennessee.

Correlation. The Cypress sandstone has been traced from the type locality in Union County, Ill., into central Kentucky closely enough to make sure of its identity throughout as far east at least as eastern Hart County, Ky., and north to Ohio River in Meade County, Ky. In the region between Hart County and the northwest corner of Barren County on the northwest and the northwestern corner of Overton County, Tenn., on the southeast is a gap of about 50 miles across Barren and Monroe counties, Ky., and Clay County, Tenn., which is not bridged by any known occurrence of the Cypress. It is possible and probable that it is carried in the top of some of the high knobs in Clay or Pickett counties, Tenn., or perhaps also in the western part of Clinton County, Ky. However, the position of the Cypress in Overton County, Tenn., immediately above the Gasper oolite, as the Cypress is in western Kentucky, strongly supports the identification of the Overton County sandstone as Cypress. This identification is corroborated by the further fact that locally in Overton County there is a second sandstone about 30 feet above the Cypress in the position of the Hardinsburg sandstone, which holds a similar position in Breckinridge County, Ky. In both the Tennessee and Kentucky localities the Hardinsburg or its horizon is succeeded above by the Glen Dean, and everywhere unmistakably identifiable limestone.

The Cypress is the same as the "Newman" sandstone lentil of the Newman limestone of the Standingstone and Wartburg folios of the U. S. Geological Survey, and is probably the same

as the Hartselle sandstone of Alabama. Both the Cypress and Hardinsburg sandstone extend clear or nearly across Tennessee, one being present in one locality, the other in another, and both being present in some localities, separated by 30 feet or less of shale and limestone. In places in Alabama, as in the vicinity of Bangor, Blount County, and Frankfort, Colbert County, a sandstone reaching a thickness of 5 feet, occurs 5 to 20 feet above the main body of the Hartselle, from which it is separated by clay and thin limestone. The upper sandstone is succeeded above by the Bangor limestone, which includes in the bottom the equivalent of the Glen Dean, so that the upper sandstone may be Hardinsburg, the clay representing the Golconda, and the main sandstone, the Hartselle, representing the Cypress. This is the writer's present interpretation.

GOLCONDA FORMATION

Name. The Golconda formation was named from Golconda, Ill. It was agreed upon by a number of geologists interested in Mississippian stratigraphy in 1916, and was first used by Ulrich in 1915 in a paper read before the Geological Society of America, but not published. In its type locality and throughout western Kentucky the Golconda is definitely bounded below by the Cypress sandstone and above the Hardinsburg sandstone.

Distribution. The Golconda formation is present in Kentucky as far east as western Warren County, whence it extends north to Ohio River in Meade County. East of the Bluegrass region and of the Nashville basin in Tennessee its presence, although it is believed, is not so surely established. This belief is based on the presence of a thin bed of marly green shale containing streaks of red shale and in places some limestone. This shale overlies the Cypress in Overton County, Tenn., and in that county is beneath a second sandstone, locally present, correlated with the Hardinsburg sandstone. Where the lower sandstone is absent, as it is locally in the northwest corner of Fentress County, the shale directly overlies the Gasper oolite, and where the supposed Hardinsburg sandstone is absent the shale is overlain by the Glen Dean limestone. The stratigraphic relations of this shale are therefore strictly analogous to that of the Golconda formation. The shale is shown in the columnar

section of the Standingstone folio, No. 53 of the U. S. Geological Survey, where it is included in the Newman limestone. Moreover, about 3 miles southeast of Cowan, Tenn., on the railroad to Sewanee, a bed of shale and limestone 30 feet thick, carrying a fauna according to Ulrich of strong Golconda affinities, rests directly upon the Gasper oolite and is overlain by 8 feet of sandstone, which, in turn, is overlain by typical Glen Dean limestone. The sandstone therefore corresponds in position to the Hardinsburg. Furthermore, about 3 miles northeast of Cowan on a high spur, the limestone and shale similar to that southeast of Cowan and carrying some of the same fossils, is both overlain and underlain by thin sandstones corresponding in position to the Cypress and Hardinsburg. At Cowan tunnel, too, the limestone and shale supposed to be Golconda are thicker amounting to 58 feet with 23 feet of shale at bottom.

Although Cowan is about 115 miles south of the locality in Overton County where the supposed Golconda shale has been observed, yet the fact that the shale and limestone of probable Golconda age at Cowan is in the same sequence as that in Overton County and partakes largely of its character, justifies the correlation of the two.

Character. The Golconda formation in eastern Kentucky is mainly a soft green shale, which is present at the tap of the Gasper in every section examined from Overton County, Tenn., to Carter County, Ky. In the southern counties it makes a bench on the slopes which doubtless is continuous into Tennessee, where it is a still more prominent feature.

In addition to the shale, there is in some sections, as between Somerset and Mt. Vernon and in the vicinity of the latter, a few feet of thick-bedded yellow limestone with *Archimedes lativolvis* or *A. swallowanus* and *A. Terebriformis* that may belong in the Golconda. The presence of Archimedes, which is very scarce in the Gasper, and the different character of these upper few feet of limestone from the typical Gasper, are the main reasons for thinking that the layers in question may be Golconda. If such is the case the place of the Cypress sandstone would be just underneath them.

Fossils and Correlation. The shale in the Golconda is unfossiliferous, and unless the yellow limestone layers are Golconda

it is without fossils in this region. The yellow limestone layers beneath the shale mentioned above have yielded the fossils of the following list:

Agassizocrinus sp.?
Pentremites sp.?
Archimedes lativolvis or *A. swallowanus.*
Archimedes terebriformis.

The material is mostly too poor for satisfactory determination. If the doubtful species is really *A. lativolvis,* it would support the idea that these beds are of Golconda age for that species is regarded as rather characteristic of the Golconda.

In June, 1922, and since the above was written a fortunate discovery by the author of *Pterotocrinus capitalis* in this shale and limestone bed at the north end of Lookout Mt., Tenn. has proven that the bed is Golconda. *P. capitalis,* hitherto known only in southern Illinois and Western Kentucky, is the most distinctive and reliable guide fossil of the Golconda.

GLEN DEAN LIMESTONE

Name and Limits. The name Glen Dean was introduced by Butts[42] in 1917, from the village of Glen Dean, on the Fordsville branch of the Louisville, Henderson and St. Louis Railroad, in Breckinridge County, Ky. In western Kentucky the Glen Dean is definitely bounded above and below by persistent sandstone strata, namely, the Hardinsburg sandstone below and the Tar Springs sandstone above. East of the Bluegrass region it is bounded below by the Golconda shale and above by shale of similar character in the bottom of the Pennington formation, or, where these beds are wanting, by the basal beds of the Pennsylvanian Pottsville sandstone. The Glen Dean is unconformable on the Golconda, through the absence of the Hardinsburg sandstone. Where it is unconformably overlain by the Pottsville, as from Kentucky River, northward into Carter County, stream channels were in places worn into its surface which were filled by the basal layers of the Pottsville. An

[42] Butts, Charles, The Mississippian formations of Western Kentucky. Kentucky Geol. Survey, p. 97, 1917.

example, illustrated in Plate 81, (frontispiece) is finely revealed in the south bank of Kentucky River just below the Government dam at Heldelberg.

Distribution. The Glen Dean is possibly the most widely distributed unit of the Chester Group. It extends from east to west the entire distance from Mississippi River in southern Illinois to Virginia, and from northern Kentucky to central Alabama. It is widely present throughout the region outlined, and is fairly uniform in lithologic character throughout and carries the same assemblage of fossils. Its outcrop west of the Bluegrass country lies through Meade, Breckinridge, Grayson, western Hart, Edmonson, and northern Warren counties; east of the Bluegrass country it outcrops high up on the knobs and spurs, close beneath the Pottsville or "Coal Measures," from the state line northward to Carter County, where a few feet of limestone of Glen Dean character are present directly beneath the Pottsville.

Character. The character of the Glen Dean is uniform in the regions covered by this report. It is almost wholly a thick-bedded to moderately thick-bedded predominantly blue, coarse-grained, fossiliferous limestone with some thin shale partings. Plate 81 gives an idea of its bedding character. In eastern Kentucky generally, near the bottom, is 10 feet or so of limestone that weathers shelly. This bed persists as far north as Owsley branch, east of Berea. There is considerable shale in the Glen Dean in places in Breckinridge County, as at and in the vicinity of Glen Dean, the type locality. At other points in the same county it is practically all limestone. At Sloans Valley, Pulaski County, it carries a bed of shale and thin limestone near the top that is highly fossiliferous and the source of the fossils of list No. 40, column 5. (See Plate 82.) At Pineville, Ky., Cumberland Gap, and Big Stone Gap, Va., it is a succession of limestone and calcareous shale beds underlying the Pennington formation. (See sections Nos. 45 and 46, section chart.)

Thickness. In Breckinridge County the Glen Dean is 100 to 150 feet thick. It is about 100 feet at Glen Dean. In the northwest part of Warren County it is about 50 feet. It is 140 feet in Overton County, Tenn., but only 63 feet at the north end

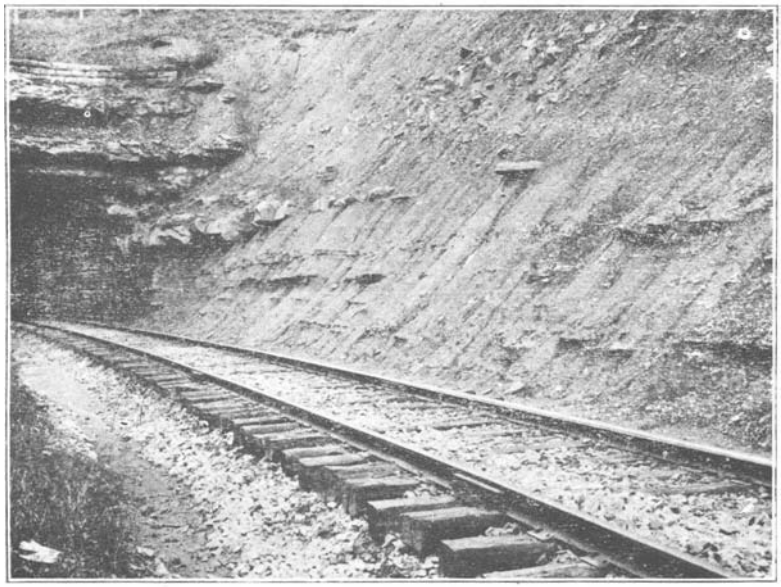


Plate 82. Glen Dean limestone and shale. North end of tunnel on the Cincinnati Southern Railroad at Sloans Valley, Ky. Looking south. This bed is the source of the many Glen Dean fossils obtained at Sloans Valley.

of Wray Hill, one mile south of Monticello, 35 feet at Mt. Vernon, and 48 feet on Kentucky River at Yellow Rock a few miles west of Beattyville. At Carter quarry is, in descending order, a 5-foot massive layer of limestone of Glen Dean character, 5 feet of marly shale, and below the shale about 3 feet of dark thin-bedded limestone, the whole resembling much more closely the Glen Dean than the Gasper. If this is Glen Dean it makes the full thickness exposed 13 feet. It may be somewhat but not much thicker, for Pottsville sandstone outcrops on the slope only a few feet above the limestone.

Fossils and Correlation. The Glen Dean is in localities highly fossiliferous and at some of these localities a great number of species have been collected. Probably the locality that has yielded the greatest number of species is Sloans Valley, in Pulaski County, where the material was derived from the railroad tunnel. (See Plate 82.) Collections from six localities distributed at fairly regular intervals from Mississippi River

to Cumberland Gap in southeastern Kentucky are listed. The lists, (except column 6,) and the distribution of the species are shown in the following table quoted from Ulrich Mississippian Series of western Kentucky, pages 226 to 230. Columns 1 to 6, one for each locality, are arranged in order from west to east. Column 1 is for Randolph County, Ill.; column 2,

LIST NO. 40.

List of Glen Dean Fossils from Various Localities Quoted from Ulrich Except Column 6.[1]

	1	2	3	4	5	6
Zaphrentis spinulifera Edwards & Haime		X	X	X		X
Acrocrinus shumardi Yandell				X	X	
Agassizocrinus conicus Wachsmuth & Springer	X	X	X	X	X	
Agassizocrinus gibbosus Hall	X				X	
Agelacrinites pulaskiensis Miller and Gurley	X			X		
Decadocrinus milleri Wetherby	X			X		
Eupachycrinus boydi Meek and Worthen					X	
Eupachycrinus gracilis Wetherby	X			X		
Eupachycrinus maniformis Yandell & Shumard					X	
Eupachycrinus spartarius Miller					X	
Hydreionocrinus depressus Wtherby (Hall?)						
Hydreionocrinus wetherbyi Wachsmuth and Springer					X	
Onychocrinus pulaskiensis Miller and Gurley					X	
Pachylocrinus spinfer Wetherby					X	
Pentremites angularis Lyon		X		X		
**Pentremites brevis* n. sp. Ulrich	X			X	X	X
Pentremites calycinus Lyon?				X		
**Pentremites canalis* n. sp. Ulrich	X			X	X	X
Pentremites cervinus Hall	X	X		X		
Pentremites cherokeeus Hall	X			X	X	
Pentremites clavatus Hambach	X			X		
Pentremites elegans Lyon	X	X		X	X	
Pentremites fohsi Ulrich	X	X			X	
Pentremites hambachi n. sp. Ulrich	X			X		
**Pentremites lyoni* n. sp. Ulrich	X	X	X		X	
Pentremites marionensis Ulrich		X				

[1] The fossils whose names are preceded by an * are confined to the Glen Dean.

	1	2	3	4	5	6
Pentremites n. sp. aff. ***Pentremites obesus*** Lyon					X	
Pentremites obesus modestus n. var. Ulrich		X		X	X	
Pentremites pyramidatus Ulrich	X	X	X		X	X
Pentremites pyramidatus var. planulatus n. var. Ulrich	X			X	X	
	X			X	X	
**Pentremites robustus hemisphericus* Ulrich				X	X	
**Pentremites robustus* Lyon	X				X	
Pentremites simulans n. sp. Ulrich	?X			X		
**Pentremites spicatus* n. sp. Ulrich	X			X	X	
**Pentremites subplanus* n. sp. Ulrich	X				X	?X
Pentremites tulipaeformis Hambach					X	
Poteriocrinus? anomalus Wetherby					X	
Poteriocrinus? pulaskiensis Miller and Gurley					X	
Poterlocrinus? vagulus Miller and Gurley					X	
**Pierotocrinus acuts* Wetherby	X			X	X	
**Pterotocrinus bifurcatus* Wetherby	X	X	X	X	X	
Pterotocrinus depressus Lyon and Casseday				X		
Pterotocrinus pyramidalis Lyon and Casseday		X			X	
**Pterotocrinus spatulatus* Wetherby					X	X
Pterotocrinus wetherby Miller and Gurley					X	
Scytalocrinus wachsmuthi Wetherby					X	
Scytalocrinus wetherbyi Miller					X	
Taxocrinus wetherbyi Miller and Gurley					X	
Zeacrinus cylindricus Miller and Gurley					X	
Zeacrinus durabilis Miller and Gurley				X		
Zeacrinus florealis Yandell and Shumard					X	
Zeacrinus kentuckyensis Miller and Gurley	X			X		
Zeacrinus magnoliaeformis Owen and Norwood				X		
Zeacrinus ovalis Lyon and Casseday					X	
Zeacrinus peculiaris Miller and Gurley					X	
Zeacrinus pulaskiensis Miller and Gurley			X			
Anisotrypa n. sp.	X	X		X	X	
Anisotrypa solida Ulrich	X	X		X	X	
Anisotrypa symmetrica Ulrich	X	X		X	X	X
Archimedes communis Ulrich	X				X	
Archimedes compactus Ulrich	X	X			X	X
Archimedes distans Ulrich	X	X	X		X	
Archimedes intermedius Ulrich	X		X	X		
Archimedes invaginatus Ulrich	X	X	X	X		
Archimedes laxus Hall	X	X	X	X		

	1	2	3	4	5	6
Archimedes meekamus Hall	X				X	
Archimedes proutanus Hall	X	X		X		
Archimedes cf. *swallowanus* Hall	X	X		X	X	
Archimedes tarebriformis Ulrich		X			X	
Batostomella abrupta Ulrich	X				X	
Batostomella nitidula Ulrich	X			X		
Batostomella sp.?	X	X			X	
Batostomella spinulosa Ulrich				X	X	
**Chilotrypa hispida* Ulrich		X				
Dichotrypa sp.?						
Eridopora aff. *marcrostmoa* Ulrich (has smaller zoocia)		X			X	
	X	X			X	
**Eridopora macrostoma* Ulrich	X			X	X	
Eridopora punctipora Ulrich		X	X			
Fenestella aff. *conradi* Ulrich	X	X	X		X	
Fenestella aff. *multispinosa* Ulrich	X	X		X	X	
Fenestella cestriensis Ulrich					X	
Fenestella cf. *compressa* Ulrich		X				
Fenestella elevatipora Ulrich				X	X	
Fenestella flexuosa Ulrich	X	X		X	X	X
Fenestella serratula Ulrich	X	X		X	X	X
Fenestella tenax Ulrich	X	X	X	X	X	
Fistulipora excellens Ulrich		X				
Fistulipora n. sp.		X		X	X	
Hederella sp.	X	X	X		X	
Lioclema araneum Ulrich	X				X	
Lyropora divergens Ulrich				X		
Lyropora ovalis Ulrich	X	X		X		
Lyropora quincuncialis Hall	X			X	X	
Lyropora ranosculum Hall	X				X	
Lyropora subquadrans Hall	X	X	X		X	
Meekopora approximata Ulrich	X	X		X	X	
**Meekopora clausa* Ulrich				X	X	
Meekopora n. sp.	X	X		X	X	
Polypora approximata Ulrich	X		X	X	X	
Polypora cestriensis Ulrich	X	X		X		
Polypora corticosa Ulrich	X			X	X	
Polpora spinulifera Ulrich	X	?		X		
Polypora tuberculata Prout	X		X	X	X	
Prismopora serrulata Ulrich				X	X	X
Rhombopora armata Ulrich	X	X		X	X	
Rhombopora minor Ulrich	X	X		X	X	

	1	2	3	4	5	6
Rhombopora persimilis Ulrich	X	X		X	X	
Rhombopora tabulata Ulrich	X	X		X	X	
Rhombopora teniurama Ulrich	X	X		X	X	
Septopora biserialis nervata Swallow Ulrich var.				X	X	
Septopora cestriensis Prout?	X		X		X	
Septopora decipiens Ulrich				X	X	
Septopora robusta intermedia Ulrich				X	X	
Septopora subquadrans Ulrich	X	X			X	
Sphragiopora parasitica Ulrich	X	X			X	
**Stenopora ramosa* Ulrich	X			X	X	X
Stenopora rudis Ulrich					X	
Stenopora tuberculata Prout	X	X	X	X	X	
Stictoporella? undulata Ulrich				X		
Streblotrypa distincta Ulrich	X		X			
Streblotrypa nicklesi Ulrich	X		X	X	X	
Streblotrypa subspinosa Ulrich	X				X	
Thamniscus furcillatus Ulrich	X			X	X	
Thamniscus ramulosa Ulrich	X			X	X	
Vinella sp.				X	X	
Camarophoria explanata (McChesney)		X				X
Chonetes chesterensis Weller					X	
Cliothyridina sublamellosa (Hall?)		X			X	X
Composita subquadrata (Hall)		X				X
Composita trinuclea (Hall?)						X
Crania chesterensis Miller and Gurley	X	X			X	
Diaphragmus elegans var. (Shumard)		X		X	X	
Dielasma cf. *formosa* (Hall)		X			X	
Dielasma shumardanum (Miller)		X	X			
Eumetria vera or *verneuliana* (Hall)?		X			X	X
Girtyella cf. *brevilobata* (Swallow)		X			X	
Productus ovatus Hall	X	X	X	X	X	
Productus scabriculus Martin?		X	X		X	
Reticularia setigera Hall	X				X	
Spirifer aff. *breckinridgensis* Weller		X				
Spirifer increbescens Hall	X	X	X	X	X	
Spirifer increbescens var. (very elongate)			X			
Spiriferina aff. *spinosa* (hinge very short)		X				
Spiriferina spinosa Norwood and Pratten	X	X				X
Spiriferina transversa McChesney	X	X				X
Spirorbis sp.		X			X	
Allorisma sp.			X			
Aviculopecten sp.		X				

	1	2	3	4	5	6
Bellerophon sp.		X				
Euomphalus sp. aff. *E. planodorsatus* Meek and Worthen		X				
Platyceras sp.		X			X	
Pleurotomaria n. sp. (related to *P. chesterensis*) Meek and Worthen		X				
Orthoceras sp. (small simple type)		X			X	
Bairdia cestrinsis Ulrich					X	
Beyrichia? simulatrix Ulrich				X		
Beyrichiella confluens				X		
Hollina radiata var. *cestriensis*				X		
Kirkbya oblonga var. Ulrich				X		
Kirkbya tricollina Ulrich				X		
Kirkbya venosa Ulrich				X		
Moorea granosa Ulrich	X			X		
Primitia granimarginata Ulrich				X		
Ulrichia emarginata Ulrich				X		
Phillipsia sp.				X		

Smithland, Livingston County, Ky.; column 3, Belleville Spring, 7 miles north of Princeton, Caldwell County; column 4, Grayson County; column 5, Sloans Valley, Pulaski County; and column 6, Cumberland Gap, Kentucky-Virginia. The names in this list preceded by an asterisk are known only in the Glen Dean. A few other forms as *Prismopora serrulata* and *Archimedes laxus* are rare in any other zone in the Chester group so that the occurrence of either makes it highly probable that the rocks containing it are Glen Dean. The Glen Dean of Cumberland Gap and Big Stone Gap underlies the Pennington and is represented in the Newman limestone. This fact is proven by the occurrence of the starred fossils in column 6, as well as by *Prismopora serrulata*, which for practical purposes is a Glen Dean fossil. The Bangor limestone of Alabama also corresponds to or at least includes the Glen Dean. At Cumberland Gap and Big Stone Gap, Va., there are no representatives of the Cypress sandstone, Golconda formation, and Hardinsburg sandstone, so that there is between the Gasper oolite and the Glen Dean a stratigraphic gap or unconformity equivalent to

fully 250 feet of rock strata in southern Illinois, as can be seen by an examination of section No.1, section chart. The Glen Dean may enter into the composition of the Maxville limestone of Ohio, but that limestone seems to be chiefly the equivalent of the Gasper oolite.

THE BIG LIME

The oil well drillers apply the name Big Lime to the persistent limestone underlying the "Coal Measures" of the eastern Kentucky coal field. It is the limestone outcropping as a conspicuous cliff along the west slope of Pine Mountain. It is generally recorded in well logs as in the neighborhood of 200 feet thick, although in some wells it is not recorded or the record is of such a character as to indicate that the limestone is absent and that it might be actually the fact for it may have been eroded away before the coal measures were laid down as is somewhat more fully explained beyond.

It is clear from the preceding description that the Big Lime is made up of the St. Louis limestone, Ste. Genevieve limestone, the Gasper oolite and the Glen Dean limestone.

PENNINGTON FORMATION

Name and Limits. The name Pennington was introduced by Campbell[43] in 1893 from Pennington Gap, Va.

In Virginia the Pennington includes all the rocks of Mississippian age between the top of the Newman limestone and the base of the Pottsville rocks "Coal Measures." It has been shown that in that region the upper half or thereabouts of the Newman is of the age of the Glen Dean limestone.

Distribution. The Pennington of central Kentucky is limited to the western escarpment of the Cumberland Plateau and outcrops from the Kentucky-Tennessee line northward as far as the latitude of Berea, where it apparently feathers out. In Breckinridge County the Pennington of the eastern belt through Clinton, Wayne, Pulaski counties, etc., is represented by the Buffalo Wallow formation. (See Sec. No. 5 on large chart, etc.) The Pennington outcrops along the west face of Pine Mountain from the Breaks of Sandy to Tennessee.

[43] U. S. Geol. Survey Bull. 111, pp. 28, 37.

Character. The Pennington formation through Clinton, Wayne and Pulaski counties and to its northern limit is composed mainly of shale, but includes a smaller proportion of limestone and sandstone. The shale is largely soft, green, marly, but there are layers of red shale. The limestone is generally argillaceous, some is red, some is bluish, crystalline, and fossiliferous, some is light-gray and of lithographic texture when fresh. The sandstone is fine grained and usually laminated or shaly. The red color of the shale and limestone is characteristic of the Pennington from Virginia to Alabama and of the equivalent Buffalo Wallow formation of western Kentucky. It is a southern extension of the red color of the Mauch Chunk shale of Pennsylvania, to part of which the Pennington is equivalent.

Thickness. The greatest thickness of Pennington measured is at Monticello and Burnside where it is 140 and 135 feet respectively. The measurement at Burnside is especially reliable for both top and bottom could be seen there. The formation thins northeastward to 35 feet at Mt. Vernon, (Sec. No. 27, section chart), and about the same thickness seemed referable to the Pennington at Morrill, southeast of Berea, (Sec. No. 34, section chart.) To the northeast of Morrill the Pennington was not identified. At Cumberland Gap the Pennington is about 200 feet thick and at Big Stone Gap, Va., is about 1,100 feet thick.

Fossils and Correlation. The Pennington in middle Tennessee and east-central Kentucky is not very fossiliferous and no fossils were collected from it in Kentucky or in Overton County, Tenn. In Breckinridge County, Ky., however, such characteristic upper Chester fossils as *Composita subquadrata* and *Spirifer increbescens,* very large, robust forms, occur in the equivalent Buffalo Wallow formation, and there can be no reasonable doubt that the east-central Kentucky Pennington is partly equivalent to the upper Chester of the Ohio and Mississippi Valleys, that is, it falls into that part of the Chester above the Glen Dean limestone and extends at least as high as the Clore limestone. Whether it includes in the lower part the equivalent of the Tar Springs sandstone is not determinable. The Pennington of the Pineville and Cumberland Gap sections

also probably extends at least as high in the section as the Clore limestone of Mississippi Valley, and at Big Stone Gap, Va., where it is about 1,100 feet thick, it may include beds in the upper part as young as any in the type region of the Mississippian series exhibited in section No. 1 of the section chart. The Pennington falls within the limits of the Mauch Chunk red shale of Pennsylvania and probably within the upper half or two-thirds of the Mauch Chunk.

RELATIONS OF THE CHESTER GROUP TO THE MAUCH CHUNK SHALE OF PENNSYLVANIA

The view has already been expressed, page 155, that the Ste. Genevieve limestone of central Kentucky is the equivalent of the Loyalhanna limestone of Pennsylvania, which lies upon the Burgoon sandstone (Pocono, Big Injun sand.) The equivalent or the Burgoon is the Logan formation of Ohio and Kentucky, which has been shown to be not younger than lower Burlington of Mississippi Valley. There is in Pennsylvania, therefore, between the Loyalhanna and the Burgoon sandstone, a stratigraphic break equal to the upper Burlington, Keokuk, Warsaw, and St. Louis formations of Mississippi valley, which are absent in Pennsylvania.

In Pennsylvania the nearest point to the Ohio and Kentucky outcrops of the Ste. Genevieve at which the Loyalhanna outcrops is on Chestnut Ridge, in Fayette and Westmoreland counties, in the vicinity of Connellsville. In that part of Pennsylvania and in western Maryland the Loyalhanna is immediately overlain by red shale, the basal Mauch Chunk, about 40 feet thick. The red shale is succeeded by the Greenbrier limestone lentil, some 50 feet thick in Pennsylvania but considerably thicker in Maryland. Above the Greenbrier limestone is more red shale extending up to the Pottsville sandstone. The whole is classed as Mauch Chunk, which, 100 feet thick or so in southwestern Pennsylvania, is only a fraction of the whole Mauch Chunk, which is 2,200 feet thick in eastern Pennsylvania.

The Greenbrier limestone is by its fossils correlated with the Maxville limestone of Ohio, which is in the main the same as

the Gasper oolite of Kentucky. If the correlation is correct it follows that the Mauch Chunk extends downward at least to the base of the Gasper, and probably the top of the Ste. Genevieve limestone. The top of the Mauch Chunk in the region of its maximum thickness should extend at least as high as the top of the Pennington of southwest Virginia and the top of the Chester of Mississippi and Ohio Valleys.

UNCONFORMITY BETWEEN THE MISSISSIPPIAN AND PENNSYLVANIAN

As has been referred to in a number of places in the preceding pages, the Pennsylvanian ("Coal Measures") rocks, of which the basal part constitutes the Pottsville formation or group, rests upon different members of the Mississippian series in eastern Kentucky. From Wayne County to Rockcastle Co. the Pottsville is in contact with the Pennington; at the Pinnacle, 2 miles east of Berea, the Pottsville, here represented by the Rockcastle conglomerate member, the top formation of the Lower Pottsville, rests upon the Gasper oolite; on Kentucky River at Irvine and Heidelberg, on Morris Mountain, and at Olive Hill and Carter, it rests upon the Glen Dean limestone. At Rothwell, Menifee County, it rests on Ste. Genevieve or St. Louis at points not over one-half mile apart. At Deep Cut, on the Kinniconick branch of the Chesapeake and Ohio Railroad, 4 miles west of Carter, Carter County, the Pottsville is in contact with the Ste. Genevieve; and at Portsmouth it is in contact with the Logan formation, while at Limeville (Tongs P.O.), a few miles east of Portsmouth, 20 to 25 feet of Ste. Genevieve intervene between the Pottsville and Logan.

From the scattered data enumerated in the preceding paragraph it is plain that the Pottsville northward and eastward from southern Kentucky and westward from eastern Kentucky comes into contact with successively lower members of the Mississippian series from the Pennington down to the lower Burlington, (Logan).

The explanation is that after the deposition of the Mississippian series, which certainly extended a considerable distance westward over the Bluegrass region, nearly all of the central United States was raised above sea level and became land,

from which the Mississippian strata were beveled off by erosion so that different members of the series formed the surface of the land in different areas. Besides the general beveling, stream channels were entrenched in the surface as at the present time. After a time the Pottsville rocks creeping slowly westward from Virginia and West Virginia were laid down upon the old eroded surface, and naturally came successively into contact with older and older strata to the northwestward in the course of their transgression. The lower parts of the land and the old valleys were naturally first filled up. One of these old filled valleys has been fortunately uncovered by Kentucky River at Heidelberg, and the Pottsville rocks, with coal beds, filling the old channel are plainly revealed. A photograph of the filled channel in the Glen Dean limestone is exhibited in the frontispiece, (Plate 81.)

The general relations of the Mississippian and Pennsylvanian brought about by the activities outlined above are illustrated in Fig. 7.

Fig. 7. Diagrammatic section across the eastern Kentucky coal field from South Portsmouth south eastward. Shows the unconformable relation of the Mississippian and Pottsville (coal measures).