CHESTER IN POPE AND JOHNSON COUNTIES

By

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MANUSCRIPT #8

1922-24 ± ?

Pope and Johnson Counties

Renault . . . . . ~~7~~ 4

Bethel . . . . . ~~19~~ 12

Paint Creek . . . . . ~~26~~ 16

Cypress . . . . . ~~37~~ 22

Golconda . . . . . ~~43~~ 26

Hardinsburg . . . . . ~~54~~ 33

Glen Dean . . . . . ~~60~~ 37

Tar Springs . . . . . ~~69~~ 42

Vienna . . . . . ~~74~~ 46

Waltersburg . . . . . ~~83~~ 52

Menard . . . . . ~~91~~ 57

Palestine. . . . . ~~98~~ 62

Clore. . . . . ~~102~~ 65

Degonia . . . . . ~~107~~ 68

Kinkaid . . . . . ~~112~~ 71

Topography of Pope and Johnson Counties

The topography of Pope and Johnson Counties is in the stage of maturity, with the general surface sloping from the north to the south, towards the Ohio River. The more rugged, northern portion of the counties is underlain by the Pottsville rocks. South of the Pottsville area, a belt ten or more miles in width is underlain by the Chester series of formations, a succession of resistant sandstones alternating with much less resistant limestone and shale formations, all having a general dip to the north. Across this belt the surface consists of a series of sub-parallel, east-west escarpments controlled by the sandstone formations in the series. Each escarpment rises with a more or less abrupt slope, in some places as nearly vertical cliffs of sandstone above, facing in a southerly direction, the surface beyond the escarpment, to the north, by a gently sloping, more or less dissected plane, the angle of slope being essentially the angle of dip of the rock strata. The less resistant limestone and shale formations of the series outcrop beneath the sandstone in the escarpment slopes, and consequently occupy comparatively narrow belts on the surface, between the much broader belts of sandstone.

The east-west continuity of the series of escarpments and cuesta slopes is much interrupted in places by the faulting of the region, and where the faulting is most pronounced there seems to be but little system in the topographic forms, but when the faults themselves are taken into consideration the continuation of the offset escarpments can be recognized throughout most of the region. Because of the lesser degree of faulting to the west the more typical expression of the topographic form described, occurs in Johnson County, and continues westward into Union County.

General Time Scale			Randolph & Jackson Cos.	Johnson & Pope Cos.	Hardin Co.	
Chester Series	Upper	Kinkaid ls.	Kinkaid	Kinkaid	Kinkaid	
		Degonia ss.	Degonia	Degonia	Degonia	
		Clore ls.	Clore	Clore	Clore	
		Palestine ss.	Palestine	Palestine	Palestine	
		Menard ls.	Menard	Menard	Menard	
		Waltersburg ss.		Waltersburg		
		Vienna ls.		Vienna		
		Tar Springs ss.		Tar Springs	Tar Springs	
	Middle	Glen Dean ls.	Okaw	Glen Dean	Glen Dean	
		Hardinsburg ss.		Hardinsburg	Hardinsburg	
		Golconda ls.	limestone	Golconda	Golconda	
		Cypress ss.	Ruma ss.	Cypress	Cypress	
	Lower	Paint Creek ls.	Paint Creek	Paint Creek	Paint Creek	
		Bethel ss.	Yankeetown ch	Bethel	Bethel	
		Renault ls.	Renault form.	Renault	Renault	
		Aux Vases ss.	Aux Vases ss.			
		Ste. Genevieve ls.	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	
		St. Louis	St. Louis	St. Louis	St. Louis	

Geology of Pope and Johnson Counties, Illinois

Location. - The two counties of Pope and Johnson lie upon the southern slope of the spur of the Ozarks which extends eastward across southern Illinois from the Mississippi river to the Ohio, the northern boundaries of the county being situated near the crest of this Ozark highland. Pope County extends to the Ohio river on the south, and possesses a narrow elongate extension south of the Bay bottoms along the western side of the river where the course of the stream is nearly south. Johnson County is bounded on the south by the Cache river in the western part of that boundary, but to the east the county line has an east west course which conforms to no topographic feature. R Renault present in Pope County near Grand Pierre Creek, west and northwest of Eichorn Shetlerville also present in that region. See Hardin County map (being engraved).

Renault Limestone

Distribution. - In Pope County the outcrops of the Renault limestone are limited to small areas adjacent to the Ohio River. The easternmost of these is between the mouth of Grand Pierre Creek and the east line of the county where the limestone is exposed in the river bank at about the river level. The top of the formation rises to the east and continues to rise beyond the county line to the Shetlerville fault in Hardin County. Two other areas are present on the two sides of the Bay bottoms, along or near the Ohio river. North of these bottoms the limestone is exposed at intervals in the base of the river bluffs from the point where the bluffs which form the north wall of the Bay Creek valley make an abrupt bend and continue northward along the river to within about one mile of the town of Golconda. Throughout much of this distance the limestone is completely hidden by the talus accumulations, the most extensive exposures being on either side of the mouth of the hollow situated in NW¼ SW¼, sec. 31, T. 13 S., R. 7 E., about 1 3/4 miles below Golconda. At this locality the top of the limestone lies at an elevation of about 360 feet, approximately 40 feet above the river level. North of these outcrops, the dip of the strata carries the bed downward and the limestone is hidden entirely for a short distance north of the mouth of the hollow situated near the middle of NW¼ Sec. 31 just mentioned. The dislocation along the east-west fault crossing the SW¼ sec. 30, T. 13 S., R. 7 E., brings the Renault limestone to a higher level again and the exposures can be seen in the river bank at extremely low stages of the water.

South of the Bay bottoms the Renault limestone is exposed west of the —— fault in the valleys of Cave Creek and Barren Creek, and in the basal part of the bluff forming the south wall of Bay Creek valley. The westernmost exposure in this region is in the mouth of the hollow situated in SE¼ NW¼ sec. 22, T. 14 S., R. 6 E., about one mile above the Lackey Bridge. The limestone is again exposed in the short ravine nearly opposite this bridge and along the road southeast from the bridge. In

the valley walls of Cave Creek, the Renault is well exposed to an elevation of 420 feet at the mouth of the ravine-like portion of the valley, the exposures being especially good on the southwest side of the valley in SE¼ SE¼ sec. 27, T. 14 S., R. 6 E. In following the formation up the creek the dip of the rock strata bring the upper contact of the limestone to a lower level, and it passes beneath the overlying sandstone at an elevation of about 390 feet, about 3/4 mile upstream from the mouth of the gorge. The exposure of the Renault in the valley of Barren Creek, which forms a junction with Cave Creek before they reach the Ohio river, the situation is much as in Cave Creek, but the direction of the ——— fault is such as to exclude the Renault limestone from some of the easternmost tributaries of the stream from the south.

In Johnson County the Renault limestone outcrops only along the north wall of the Cache River valley from a point about two miles east of Indian Point to the west line of the county. This outcrop is continuous except where it is interrupted by valleys tributary to the bottoms, although the beds are obscured over considerable distances by the talus accumulations and other superficial deposits. To the eastward this line of outcrop bends more to the southeast and continues in Massac County to the Reevesville fault. The limestone is well exposed for fifty or sixty feet above the level of the Cache bottom in SW¼ sec. 34, T. 13 S., R. 3 E., and this outcrop continues westward to Indian Point with exposures at intervals, much of it being covered by talus and other surficial accumulations. At Indian Point it is exposed in the C. B. & Q. railroad cut where about 12 feet of limestone may be seen, the summit of the bed being 20 or 25 feet above the level of the Cache bottoms.

The Renault limestone forms the base of the isolated 520 foot hill lying between the C. B. & Q. and Big 4 railroads west of Indian Point, but it is only exposed towards the eastern end, although the presence of the underlying limestone is shown by a small hole which occupies the western shoulder of the hill. At Belknap the major portion of the limestone exposed in the bluff back of the town is the

Renault. This exposure continues along the Big 4 railroad track for about one mile northeast of the Belknap Station, and good exposures of it are present at the spring near the head of the ravine in NE¼ sec. 1, T. 14 S., R. 2 E. A little over one mile west of Belknap there are other good Renault exposures on the hillside east of the road in NW¼ sec. 2, T. 14 S., R. 2 E. Beyond this point to the west only occasional exposures of the formation are met with, the outcrop being covered for the most part with surficial deposits.

The best Renault exposures in the two counties are shown adjacent to the mouth of the Cave Creek ravine in Pope County, and those at and near Belknap in Johnson County.

Lithologic Character. - The lithologic character of the Renault limestone is nearly uniform throughout the extent of the formation in Pope and Johnson Counties. It is in general a hard gray limestone, more or less crystalline in texture, locally somewhat oolitic. Most of the exposed ledges are rather ~~recessive~~ massive, some of them exhibit notable cross-bedding, one of the best exhibitions of cross-bedding being in the C. B. & Q. railroad cut at Indian Point. In the upper portion of the formation there is a small amount of chert, but much of the limestone is entirely free from such inclusions. The weathered surfaces of the limestone, where washed free from the surficial covering are commonly smooth and light colored. The separate ledges of limestone seem to be separated by thin shaly partings but nowhere in the two counties has any notable shale bed been observed in the formation, although such beds may be covered. The best exposures of the formation are not in vertical bluffs or escarpments but are in the form of steep hill slopes which are covered with more or less displaced or slumped masses of the limestone with occasional ledges in places, the whole mingled with more or less talus and wash from higher rock formations and surficial accumulations. Under such conditions it is not possible to study in detail the successive beds or members of the formation, and if some thin shale beds were

present they might easily be effectively hidden.

Thickness. - Nowhere within the area of the two counties have the actual contacts between the Renault and the underlying and overlying formations been observed, so that the determined thickness of this formation must necessarily be an approximation. The best locality for making an approximately accurate determination of the thickness is in the hill slope about one mile west of Belknap where the upper portion of the Ste. Genevieve limestone is present below, and the Aux Vases sandstone above the Renault. The thickness of the formation at this locality is about 60 feet. Along the bluff above the Big 4 railroad track 3/4 mile northeast of Belknap the interval in the section which must be occupied by the Renault is apparently a little less, about 50 feet. In Pope County in SE¼ SE¼ sec. 27, T. 14 S., R. 6 E., at the south side of the mouth of the Cave Creek ravine, there is at least 60 feet of Renault limestone, perhaps a little more. Elsewhere in Pope County the Renault outcrops apparently do not continue to the base of the formation so that its entire thickness is not situated so as to be exposed.

Stratigraphic relations. - The stratigraphic relations of the Renault limestone with the underlying formation are not properly exhibited anywhere in the two counties under discussion, although the presence of an unconformity at the base of the Renault may be assumed without question, this break in the sedimentary record being the position occupied by the Aux Vases sandstone in the Randolph County section. In Hardin County, and also in Caldwell Co., Ky., the unconformity at this stratigraphic position is distinctly shown in the exposed sections, and in Hardin Co., Ill. and Crittenden Co., Ky., a formation which has been designated by the name Shetlerville is present beneath the Renault proper and above the unconformity. The Shetlerville has not been recognized anywhere in Pope or Johnson Cos., west of Grand Pierre Creek, but there is a possibility of its being present, now entirely covered with surficial materials. The Shetlerville beds in the region of their typical development are much more shaly than the Renault formation, being made up largely of shales and thinly bedded limestones, and if such beds are present beneath the Renault in the area under discussion they might easily be obscured by the talus accumulations upon the hill slopes where the outcrops might be sought for. If the Shetlerville beds really are wanting, their absence makes the unconformity between the Renault and the formation beneath just so much more of a stratigraphic break than is the unconformity exhibited in Hardin County.

The only satisfactorily exposed contact between the Renault limestone and the overlying Bethel sandstone in either Pope or Johnson Counties, is exhibited in the C. B. & Q. railroad cut in Indian Point, in Johnson County, 5½ miles south of Vincennes. At this locality the following section is well shown:

Section at Indian Point, Johnson Co.

5. Sandstone, massive, moderately coarse, yellow-brown in color, with ferruginous seams, cross-bedded, with numerous fragments of plant stems. Chester bed No. 8, or Cypress sandstone of Engelmann's section 30 feet

4. Shale, with intercalated thin beds of limestone, mostly talus covered with loose limestone slabs and an occasional outcropping ledge. Fossiliferous. Over much of the slope this bed is completely covered by the sandstone talus. Bed No. 9 of Engelmann's section 50 feet

3. Sandstone, irregularly thin-bedded, cross-bedded, in part, with some thin shaly partings. Fine-grained, yellow-brown in color, more or less calcareous. Bed. No. 10 of Engelmann's section 10 feet

2. Limestone, arenaceous, with thin, discontinuous sandy partings, the lower six inches conglomeratic, with angular limestone pebbles up to two or three inches in maximum dimensions, the contact with the bed below uneven, indicating an unconformity 1-2 feet

1. Limestone, oolitic or crystalline, much of it strongly cross-bedded, light gray in color, fossiliferous. Exposed above railroad 12 feet

In this section, bed No. 1 represents the top of the Renault limestone upon which the overlying sandstone lies unconformably, the unconformity being indicated not only by the uneven contact surface but by the presence of the basal conglomerate. This condition of unconformity between the Renault and the overlying Bethel sandstone is well exhibited outside of the area being described, in the Ohio River bluffs east of Cave-in-Rock, Hardin County, and the evidence seems to be sufficient to justify the assumption of an unconformity at this position in the Chester Series throughout the southern counties of Illinois.

Paleontology. - The Renault limestones are full of fossils, but they are commonly so firmly imbedded in the limestone that good specimens are not commonly met with. In some slightly shaly beds, or upon some weathered surfaces, fossils complete enough for identification can be secured in some places. One of the most complete collections that has been secured is from the C. B. & Q. railroad cut at Indian Point in which the following species have been recognized.

Fauna of the Renault limestone at Indian Point.

The characteristic features of this fauna are the abundance of Pentremites and the presence of a species of Talarocrinus with bilobed base. At this locality nearly or quite all of the pentremites present belong to the species P. ~~formicatosum~~ princetonensis but elsewhere some other species of the genus are met with. One of the common species to be found upon the slopes underlain by the Renault are loose masses of limestone exhibiting large numbers of pentremites of rather small size. The type of Talarocrinus mentioned above is a very characteristic member of the Renault fauna wherever the formation is exposed, from Monroe Co., Illinois at the northwest, to Hardin County at the southeastern extremity of the area of Chester rocks in Illinois. The specimens of this Talarocrinus are rarely preserved in such a condition as to permit of their certain identification, because the more essential specific characters are found upon the ventral side. The bilobed bases and the subquadrangular radial plates are the parts most commonly met with, and they are fully sufficient to permit the certain identification of this genus, and of this particular section of this genus. Judging from the comparatively few complete examples of this crinoid that are known, the genus appears to exhibit certain geographic variations which may be of specific value, but the whole group of species, so far as known, are limited in their occurrence to the Lower Chester formations, and are especially characteristic of the Renault limestone.

Another collection of Renault fossils that has been secured from Pope County, is from the exposures at the south side of the mouth of the Cave Creek ravine, in the SE¼ SE¼ sec. 27, T. 14 S., R. 6 E., 2½ miles northwest of Bay City. The following species have been identified in this collection.

Fauna of the Renault limestone 2½ miles northwest of Bay City.

(no entry in handwritten notes)

This fauna contains the very characteristic Talarocrinus of the Renault, one example preserving the basal and radial plates in position having been found. At this locality, however, the pentremites which are so common in some places, are rare.

Correlation. The questions involved in the correlation of the Renault limestone of the southern counties of Illinois have been fully discussed in the Hardin County Report, and need not be repeated here. The formation is recognized throughout the full extent of the Chester Series in Illinois, from southwestern St. Clair County on the northwest to Hardin County in the southeast. The more northwesterly outcrops, however, were nearer to the shore line of the ancient sea in which these deposits were laid down and in that region the formation varies, beds of shales and sandstones as well as limestone, while in the region here being considered, which was far from the shore lines, no sandy sediments, and but little shale was accumulated. The equivalence of the beds referred to the formation through its whole extent, is completely established by the characters of the contained fossils.

Bethel Sandstone

Distribution. In Pope County the distribution of the Bethel sandstone is limited to the eastern portion of the county near the Ohio River. The best exhibition of the formation is in the river bluffs east of the mouth of Grand Pierre Creek, where it forms an essentially vertical escarpment one hundred feet in height. This exposure continues eastward to beyond the Pope-Hardin County line to Shetlerville, and extends northward from the river along the county line for four and one-half miles. The "Shetlerville Hill" on the road from the bridge over Grand Pierre Creek to Shetlerville is on this formation, and the ravines tributary to Grand Pierre Creek from the east in sec. 34 and the southern portion of sec. 27, T. 12 S., R. 7 E. are cut into this sandstone and afford excellent exposures. Farther north the width of the outcrops is restricted by faulting, but excellent exposures may be seen at frequent intervals along the county line road.

(north of Hobbs Creek)

In the riverbluffs below Golconda the Bethel sandstone outcrops continuously to the Bay bottoms, and is present in the bluffs forming both walls of the valley of Bay Creek, on the north side of the valley extending only a little over one mile, but on the south side continuing for somewhat more than three miles. Throughout this line of outcrop the formation is overlain by the Paint Creek shale, and this again by the Cypress sandstone, so that the exposures are more or less covered by talus, but at intervals the formation is well exhibited. South of the Bay bottoms the Bethel has a much wider outcrop on the hills between the bottoms and Cave Creek, and between Cave and Barren creeks.

In Johnson County the stratigraphic position of the Bethel sandstone enters the county a little less than two miles east of Indian Point, but the sandstone itself is lacking. At Indian Point it is present, but much thinner than in Pope County, and

it continues westward to the Johnson-Union county line. The only locality in the county where it is the surface rock over any extended area is in the region just north of Belknap. Extending in both directions from Belknap there is an abrupt escarpment capped by the Bethel sandstone, which continues northward beneath the gently sloping surface to the next escarpment one and one-half miles farther north. Westward from this Bethel slope north of Belknap the Bethel and Cypress sandstones are both present in the same escarpment, as in the Ohio river bluffs below Golconda, so that the formation is limited in outcrop to a narrow band near the base of the bluff.

Lithologic character. In those situations where the Bethel sandstone has its greatest development, the formation is a rather fine grained, massive, yellowish-brown sandstone, in rather thick beds which exhibit much cross-bedding. In the river bluffs at the eastern edge of Pope County this sandstone is so massive that it forms a bluff so nearly vertical that a plumb line can be dropped for 100 feet from the top of the bluff to its base. Where the formation is thinner it is in places at least, less massive. In the exposure at Indian Point it is a thinly and rather evenly bedded sandstone. West of here the exposures are somewhat more massive in the top of the bluff back of Belknap. Perhaps the best exposure in the more western portion of Johnson County is in the north part of SW¼ of NW¼ sec. 34, T. 13 S., R. 2 E., where the formation is massive and forms a vertical bluff of much less height than that east of Grand Pierre Creek in Pope County.

Thickness. The Bethel sandstone varies from 100 feet or more to nothing. In the Shetlerville bluff at the east edge of Pope County, as has already been indicated, the formation is exposed for an actual thickness of at least 100 feet. The original thickness may have been somewhat more than this, the excess having been ~~measured~~ removed from the top of the bluff by erosion. In the river bluffs between Golconda and the Bay bottoms, 80 feet is probably about the maximum thickness, but south of the bottoms, between Cave and Barren Creeks the formation again increases in thickness

to approximately 130 feet. No more outcrops of the Bethel sandstone are known in a westerly direction from those mentioned until the Reevesville fault is past, but from this fault west the stratigraphic horizon of the Bethel is continuously present in the north wall of the Cache river valley and the extension of this valley to the east where it joins the Bay Creek valley. Where this line of outcrop enters Johnson County, a little less than two miles east of Indian Point, the Bethel sandstone is entirely wanting in the section. At Indian Point it is ten feet or somewhat more in thickness. In the top of the bluffs at Belknap the sandstone is probably about 20 feet thick, or perhaps a little more, although the exposures are such as to make it impossible to determine the thickness with accuracy, and a thickness of from 20 to 30 feet apparently persists to the west line of the county.

Stratigraphic relations. The stratigraphic relations of the Bethel sandstone with the underlying Renault limestone have already been considered in connection with the discussion of the older formation. In what is perhaps the only clear cut exposure of the contact between the two formations in the whole extent of the outcrop in Pope and Johnson Counties, in the C. B. & Q. Railroad cut in Indian Point, the unconformity between the Bethel and the Renault is clearly exhibited. An unconformity at the same stratigraphic position is well exhibited in Hardin County, to the east, and the presence of an unconformity throughout southern Illinois at this horizon is believed to be a safe conclusion.

The stratigraphic relations between the Bethel sandstone and the overlying Paint Creek shale are not so conclusively determined. No section has been observed where the actual contrast between the formations can be seen. The varying thickness of the formation might be interpreted as being indicative of an erosion period subsequent to the deposition of the Bethel sandstone, but the conditions may have been such that the original amount of sand to be accumulated may have varied in amount. That this last mentioned situation may have been the true condition is perhaps suggested

by the different character of the formation in those localities where it attains its greater thickness than where it is thin. Where the formation is thick it is very massive, but at Indian Point where it is much thinner, perhaps but little in excess of 10 feet, is for the most part a thinly bedded sandstone.

Perhaps the most significant fact bearing upon the stratigraphic relation between the Bethel ss and the overlying Paint Creek, is the presence, at least locally of conglomeratic beds in the basal part of the Paint Creek. Such beds have been observed in Hardin County, and they are also present two miles east of Indian Point, where the Bethel sandstone is wanting in the section.

Paleontology. Like the lower Chester sandstones of southern Illinois, fossils other than plant fragments are unusual in the Bethel. Independent fragments of plants and an occasional more or less poorly preserved fragment of a Lepidodendron trunk are met with. In Hardin County a number of poorly preserved examples of invertebrate fossils have been observed, brachiopods and bryozoans, but now have been seen in either Pope or Johnson Counties, although no careful search has been made for them.

Correlation. The correlation of the Bethel Sandstone is dependent entering upon the correlation of the underlying and overlying limestone or shale formations. The underlying Renault may be definitely correlated with the Renault of the Minerva and Randolph County section and the overlying Paint Creek may be just as certainly correlated with the Paint Creek formation of the same section. These correlations make the Bethel the stratigraphic equivalent of the Yankeetown of the Mississippi river section. Although the formations in the two sections are notably different, the Yankeetown being in large part a chert, and the Bethel sandstone, both are siliceous formations, and in places the Yankeetown is sandy and quartzitic. The time equivalences of the two formations may be considered as being established through the ~~center~~ correlation of the Renault and Paint Creek in the two areas.

Paint Creek Formation

Distribution. In eastern Pope County the Paint Creek formation outcrops along a narrow, sinuous belt between Grand Pierre Creek and the Pope-Hardin County line, extending northward from a point near the middle east-west line of sec. 22, T. 12 S., R. 7 E., crossing the Pope-Hardin County line south of Hicks Branch. Along this line a small exposure of the shale may be seen by the roadside in the small valley crossing the road from the Skinner bridge over Grand Pierre Creek to the Stewart Mine in Hardin County, in SE¼ NW¼ sec. 15, T. 12 S., R. 7 E. In the small ravine parallel to and just north of the road at this locality, the calcareous beds of the formation are very well exposed. In the ravine tributary to Grand Pierre Creek lying nearly parallel with and near the south line of this same section, and in the main tributary to this ravine from the northeast, there are good exposures of both of the shales and the calcareous beds of the formation. The southernmost good exposure of the formation along this belt, is in the northsouth road crossing the NW¼ sec. 22, T. 12 S., R. 7 E., about one-eighth of a mile north of the road corner at the middle east-west line of the section. In a northerly direction the shale is exposed, or its position is indicated by the topographic features in SW¼ Sec. 10, T. 12 S., R. 7 E. Beyond this there is a short interruption of the outcrop by two faults along Hobbs Creek, north of which the outcrop extends continuously without interruption to the point where it swings to a more northeastward direction and crosses the county line into Hardin County.

The formation is also exposed in Pope County along the Ohio river bluffs below Golconda. The presence of the shale formation is well exhibited at the point of the bluff just below the boat landing at the town, and is more or less continuously exposed to the point where the bluffs swing to the northwest to form the north wall of the Bay Creek valley. Through much of this distance the actual exposures of the shale are obscured by talus accumulations, but the presence of the formations may be recognized by the topography and by the bits of shale present in the wash from gullies.

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A good exposure of the shale is present about one-half mile below Golconda in the bluff beneath the cemetery. A little beyond this the position of the shale is dropped about forty feet by a nearly east-west fault. At the point of the bluff in NE¼ sec. 14, T. 14 S., R. 6 E. on the north side of the Bay bottoms, the Paint Creek shale is very well exposed in sections with the underlying and overlying sandstones, and in the ravine running ~~south~~ northwest across the south half of sec. 11, T. 14 S., R. 6 E., the shale is much in evidence in the wash and its position is exhibited in the topography although no good exposures are present.

South of the Bay bottoms in Pope County the Paint Creek shale outcrops over a considerable area in the bluffs forming the south wall of the valley and in the tributary ravines, also in the valley and tributaries of Cave Creek. The best exposures in this area occur southeast of the Homberg fault. ~~There~~ In nearly every one of the shorter and steeper ravines intersecting this bluff either actual outcrops of the shale or wash from such outcrops can be detected. In the longer ravines the shale outcrops are more completely covered, but can be ~~detached~~ exposed in places in some of the lateral tributaries. Along the public highway from Tansill to Rosebud, where it ascends the hill from the bottoms, the present of the Paint Creek Shale is well exhibited by the extensive exposures of red residual clay which is a very characteristic product of the weathering of the formation, although no exposures of the fresh shale are present. Exposures of the shale may be seen south of Independence School in the road crossing the head of Cave Creek valley, in ~~SE¼ NE¼~~, sec. 29, T. 14 S., R. 6 E. and also in the larger tributaries of this creek from the north, especially in the two whose mouths are situated in NW¼ sec. 27, T. 14 S., R. 6 E.

West of the Homberg fault the Paint Creek shale probably is present at the very base of the bluffs forming the south wall of ~~Big~~ Bay Creek valley, nearly to the Brownfield fault, but the only actual exposure of the formation is in the roadside gully, down the hill, and in the creek bank to the south, just south of Cold Spring

School, one mile west of Temple Hill. This shale doubtless forms the floor of Robnett Creek Valley, but is now entirely covered with alluvium.

In the much faulted zone bounded on the southeast and northwest respectively by the Brownfield and the Reevesville faults none of the Lower Chester formations are exposed at the surface but west of the Reevesville fault there formations are again present in the surface outcrops. In Johnson County the Paint Creek is present from Clifty Creek west to the west boundary of the county. Throughout most of the distance the formation is entirely covered by talus accumulations but its position can be recognized in the topography. A good ~~example~~ posure of the shale may be seen in the secondary ~~wall~~ road leading down the hill in a southwesterly direction across SW¼ SW¼, sec. 34, T. 13 S. R. 3 E. It is again well exposed at Indian Point, and it can be seen at intervals along the face of the bluff extending a mile east from this point. West of Indian Point the only good exposure which has been observed in the northward slope of the hill in SW¼ of SW¼ sec. 28, T. 13 S., R. 2 E., 3½ miles northwest of Belknap, but the position of the formation beneath the abrupt escarpment of Cypress sandstone can be easily determined across the whole area.

Lithologic character. The Paint Creek formation is essentially a shale throughout its entire extent in Pope and Johnson Counties, being entirely similar to the same formations in Hardin County. While the shale beds constitute by far the major portion of the formation there are in all localities where it is well exposed, subordinate layers of limestone. In some places the limestone sofar as it has been observed is a very minor part, as in the exposure in the river bluff one-half mile below Golconda. At this locality the calcareous layer does not exceed two or three inches in thickness, it is very sandy and ferruginous, being little more than a ferruginous sandstone bound together with calcium carbonate. In all the localities in Pope County where calcareous layers have been observed in the formation they are more or less sandy, but in places they are more extensive than in the bluff below Golconda. In

an outcrop east of Grand Pierre Creek, by the roadside at the bank of the creek, in the southern part of NW¼ sec. 22, T. 12 S., R. 7 E. there is a limestone ledge one or two feet in thickness. A similar limestone ledge is exposed in a ravine near the middle of the south half of sec. 15, T. 12 S., R. 7 E. and in the short tributary ravine north of the road in the north half of the same section, there are apparently several thin beds of impure limestone present. South of the Bay bottoms in Pope County, at the northwardly directed point of the bluff in NW¼ NW¼ sec. 16, T. 14 S., R. 6 E. there are numerous loose slabs of impure, fossiliferous limestone from the Paint Creek formation, but the extent of the parent ledge cannot be determined. The most extensive development of calcareous beds in the formation which has been observed anywhere in the two counties is in the face of the bluff bordering the Cache River bottoms just east of Indian Point, in Johnson County. Wherever this slope is not too deeply covered with talus from the overlying Cypress sandstone, numerous limestone slabs may be seen, and at one point a ledge of limestone three or more feet in thickness is well exposed, but along the old road leading to the top of the hill at the point, no limestone is exposed, although the shale is well exhibited. In an exposure of the formation on the slope to Little Black Slough, a little less than four miles northwest of Belknap, the characteristic beds of impure limestone are exposed, not exceeding a foot or thereabouts in thickness.

Where it is best exposed, the shale of the Paint Creek formation is very fissile, and breaks down into thin, brittle flakes an inch or two across. The color of this shale in hillside exposures is a rather dark olive green, weathering to a silvery gray color, but where the bed is so situated as to be kept wet as in the exposures in Buck Creek, east of Grand Pierre Creek, in SW¼ sec. 34, T. 11 S., R. 7 E., the shale appears to be quite black.

Not infrequently the presence of this shale is indicated in localities where it does not actually outcrop, by the character of the residual clay derived from its weathering. This clay is a deep red color, and differs in appearance from any other

residual deposit derived from the Chester series in these counties. By a process of leaching out the contained lime, the limestone beds of the formation commonly weather to a rock that is apparently a porous, ferruginous sandstone.

Thickness. In the Ohio River bluff just below Golconda the measured thickness of the Paint Creek shale is 30 feet but its actual thickness may be somewhat more than this because the contacts with neither the underlying or overlying beds are exhibited. In the section at the point of the bluffs north of Bay bottoms an interval of 35 feet between the top of the Bethel and the bottom of the Cypress sandstones is present although the actual shale exposure is only 15 feet. In the bluff on the south side of the Bay bottoms, in a very short and steep ravine in NW¼ SE¼ sec. 22, T. 14 S., R. 6 E., the interval between the two sandstones with interrupted outcrops of the shale is 75 feet but this measurement is down the dip and is consequently a little excessive. The sections along this bluff all give evidence of the presence of 60 feet or more of the Paint Creek shale. In Johnson County, in the section along the secondary road in SW¼ sec. 34, T. 13 S., R. 3 E., about two miles east of Indian Point, from 50 to 60 feet of the shale is exposed, and in the face of the bluff at Indian Point about 50 feet. Elsewhere the exposures are not sufficient to allow an accurate determination of the thickness of the bed, but the topographic features commonly suggest a shale interval of approximately 50 or 60 feet, and this may be considered to be the usual thickness of the formation, although it may be somewhat less than this in some localities in Pope County.

Stratigraphic relations. The stratigraphic relations between the Paint Creek formation and the underlying and overlying sandstones is not easy to determine by direct observation. As has already been pointed out the varying thickness of the underlying Bethel sandstone, and especially the conglomeratic layer at the base of the Paint Creek that has been observed in a number of places, suggests an unconformity at this horizon.

The contact between the shale and the overlying Cypress sandstone has been observed in only one locality in a satisfactory manner, that is in the creek bank in SE¼ of SW¼ sec. 10, T. 14 S., R. 5 E. three quarters of a mile west of Temple Hill near Cold Spring School. At this place the shale passes into thinly bedded sandstone without abrupt change, which would suggest an absence of unconformable relations. In other situations the basal beds of the Cypress seem to be somewhat thinly bedded and this condition may be general.

Paleontology. The most complete collection of fossils from the Paint Creek has been secured from the loose limestone slabs which are strewn along the face of the bluff east of Indian Point, in Johnson County. The following species have been identified in the collection from this locality.

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A small collection from the SE¼ of NW¼ sec. 15, T. 12 S., R. 7 E., east of Grand Pierre Creek, has afforded the following species.

* * * * * *

From the Ohio river bluff about one half mile below Golconda a few imperfect fossils have been collected from the thin, platy, calcareous layers, and the following forms are recognized.

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Perhaps the best collection of Paint Creek fossils that has been made in Pope County, is from NW¼ of NW¼ sec. 16, T. 14 S., R. 6 E. The species that have been identified are as follows:

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Correlation. The correlation of the Paint Creek formation of the southern counties of Illinois has been fully considered in the Hardin County Report and the discussion need not be reconsidered here. All the additional evidence that has been accumulated during the progress of detailed study and mapping of the Chester formations across Pope and Johnson Counties only serves to strengthen the conclusions stated in that report.

Cypress Sandstone

Distribution. The areal extent of the Cypress sandstone in Pope and Johnson Counties, is as great and probably somewhat greater than that of any of the other formations of the Chester Series. Wherever the formation occurs to the north of the Bay-Cache valley it presents a bold escarpment to the south or east, beyond which it dips away with a gentle slope to the base of the next succeeding escarpment of Hardinsburg sandstone. South of the Bay bottoms the sandstone forms the top part or the whole of the bluffs forming the south wall of the valley for a distance of between seven and eight miles from the Ohio river, and underlies the uplands back of the bluff to the line where it passes beneath the much younger formations of Cretaceous or Tertiary age.

The most easterly outcrop of the formation in Pope County is east of Grand Pierre Creek in a belt extending northward from near the middle of sec. 22, T. 12 S., R. 7 E. to sec. 22, T. 11 S., R. 7 E. where the outcrop swings to the east and enters Hardin County. The eastwardly facing escarpment of the sandstone in this is not so abrupt as that along the Ohio, Bay and Cache valleys, but it does occupy a distinct ridge with a gently sloping westerly side. A small area of the Cypress sandstone is present in the Ohio river bluffs just west of the mouth of Grand Pierre Creek, but the westerly dip of the strata at this place covers it beneath the overlying Golconda limestone in a short distance. Below Golconda, the Cypress constitutes the main portion of the river bluff to the junction of the Bay bottoms with the river, and from here it is present in the northern wall of the Bay Creek valley to the Homberg fault. The occurrence of the formation south of the Bay bottoms has already been mentioned.

West of the Pope County outcrops of the Cypress sandstone that have been mentioned, the formation makes its next appearance west of the Reevesville fault in Massac and Johnson Counties. In Johnson County the Cypress underlies the northwardly dipping slope which extends from Samoth, just across the line in Massac County, to the Indian Point. To the east the southwardly directed escarpment limiting this cuesta slope is situated across the line in Massac County, but it enters Johnson County about

two miles east of Indian Point, and the Cypress Sandstone forms the upper portion of the escarpment extending eastward from the Point for a little over a mile. In a westerly direction from Indian Point the Cypress outcrop is a little offset to the north by the Vincennes fault, in consequence of which the Cypress escarpment does not constitute the north wall of the Cache river valley, but lies a mile or more to the northward from the valley wall. The surfaces underlain by the formation slope gently to the north. The hill north of Forman, between that railroad junction point and the mouth of Dutchman Creek is Cypress sandstone. The larger hill northwest of Forman along whose northeastern edge the C. B. & Q. railroad passes, is also Cypress sandstone as is Boss Island to the west. Beyond here the hills both north and south of Little Black Slough are Cypress, and these hills extend westward to the town of Cypress which is situated upon and in the midst of most excellent Cypress exposures rising in escarpments. Although the main Cypress was originally given to this formation from exposures on Cypress Creek, being before the town of Cypress was established, no more typical outcrops of the formation could be chosen than those right at the town. The average width of the Cypress sandstone in this part of Johnson County is from two to three miles.

Lithologic characters. The Cypress sandstone is uniformly the most massive of any of the sandstone formations in the Chester series. Most of the other sandstones are locally massive but pass laterally in comparatively short distances, in places, into much less massive and thinly bedded sandstones or even arenaceous shales, but the Cypress is a massive, cliff forming sandstone wherever it occurs in the more southern counties of Illinois. It is moderately fair grained in texture, and has a light yellowish-brown color in freshly broken surfaces, and may even be nearly or quite white where entirely free from weathering. In some portions of the formation the beds exhibit more or less distinct cross-bedding, but elsewhere the bedding is remarkedly even. In places the sandstone includes a considerable amount of ferruginous material.

Thickness. The Cypress sandstone is one of the thickest of the formations in the Chester series, no other sandstone being uniformly so thick. Although a number of these may locally attain as great or even greater thickness. At no locality in Pope or Johnson County does the Cypress occur in a continuously exposed section with both the underlying and overlying formations. In such situations it occurs with an abrupt cliff face in one direction, with a gently sloping surface in the opposite direction, and in a number of such exposures the position of the base of the formation can be quite accurately determined, where the cliff face rises more or less abruptly for forty, sixty or more feet. Such exposures, however, do not comprise the whole thickness of the formation, for the tops of the bluffs have been subjected to weathering and may have been materially reduced in height. At the termination of the Ohio River bluffs north of the valley of Bay Creek, 70 feet of Cypress is exposed above the Paint Creek shale, and this, perhaps, is about the maximum actual exposure in the region; but there are undoubtedly higher beds than the uppermost ones in the section at this place, and a total of 80 feet is perhaps a minimum thickness at this locality and elsewhere. At one locality in Hardin County Butts has estimated the Cypress sandstone to be 110 feet in thickness, and it is not unlikely that the formation is at least 100 feet thick throughout the greater part of its extent in Pope and Johnson Counties.

Stratigraphic relations. No convincing evidence has been secured to show that relatives of unconformity exist between the Cypress sandstone and either the underlying Paint Creek or the overlying Golconda formations. The observations that it has been possible to make suggest the absence of any stratigraphic break either below or above the formation. The conditions of the transition from the Paint Creek to the Cypress have already been mentioned. Above the Cypress there are sandy beds with fossils which seem to recur in the basal portion of the Golconda in some localities in eastern Pope County in the environs of Golconda, which would indicate gradually changing conditions from the Cypress to the Golconda. At one locality in Johnson

County, however, in NE¼ sec. 25, T. 13 S., R. 3 E., some masses of a limestone conglomerate have been observed from the base or near the base of the Golconda limestone, which may be associated with an unconformity, but without additional information it would be unsafe to consider any such relation as established.

Paleontology. The only fossils that are commonly met with in the Cypress sandstone are fragmentary plant remains, in most cases too imperfect to permit even a determination of their nature, but in places very fragmentary remains of marine organisms are present, chiefly bryozoan fragments.

Correlation. The correlation of the Cypress sandstone must be based upon the correlation of the underlying and overlying more fossiliferous formations. A consideration of the contained faunas firmly establishes the equivalence of their beds with the Paint Creek, and Lower Okaw limestone respectively, in the Randolph County section, between which is the Rinera sandstone, and this sandstone formation may be considered as an equivalent of the Cypress, much reduced in thickness.

The Golconda Limestone

Distribution. The Golconda is a nonresistant formation whose outcrop is situated along the lower slope of the escarpment determined by the more resistant, overlying Hardinsburg sandstone. Because of this situation the actual exposures of the formation are somewhat limited. In many places the lower slopes of the escarpment where the formation occurs are completely covered by talus from the overlying sandstone, so that no exposures are visable for stretches of several miles, but where the escarpment is very steep, and especially where some ~~strain~~ eam is cutting, or has recently cut into the base of the cliff and has removed the talus accumulations, very good exposures can be seen. Other good exposures are to be found where gullies or larger valleys have intersected the escarpment.

The escarpment in which the Golconda formation is present enters Pope County from the east at the valley of Brushy Fork, about three miles south of the northeastern corner of the county. From here it continues in a southerly direction, forming the west wall of the valley of Big Grand Pierre Creek to the Ohio river, except where it is locally interrupted by faulting. A continuation of this escarpment is exhibited in the Ohio river bluff from a point 3/4 of a mile below the mouth of Grand Pierre Creek to the valley of Lusk Creek at Golconda. Throughout this stretch the formation is very well exposed because of the removal of much of the talus accumulated by the river. From Lusk Creek the escarpment in which the Golconda occurs continues along the northwest wall of the valley of Miller Creek, and of an unnamed creek tributary to the Bay Creek, to Homberg, then swings to a more westerly direction to Brownfield. West of Brownfield this Golconda-Hardinsburg escarpment is interrupted by the downdropped fault blocks between the Brownfield and Reevesville faults, but beyond the latter fault the same escarpment reappears and continues across southern Johnson County from Georges Creek, in a slightly northwesterly direction to the western border of the county a little distance north of Cypress.

The widest extent of outcrop along the entire belt that has been indicated, is found in the hill occupying the SW¼ sec. 10, T. 13 S., R. 2 E., two miles south of West Vienna, and extending in a southwesterly direction into the adjoining sections 15 and 16. This area of outcrop is more than one mile in length, but elsewhere the belt of actual outcrop nowhere exceeds one-half mile, and throughout much of the distance it is less than ¼ mile in width. This belt is much narrower than that of the underlying Cypress sandstone, although the average thickness of the Golconda is probably as great as the Cypress.

Lithologic character. One of the reasons for the poor exposures of the Golconda is the lithologic character of the formation, it being a series of interbedded limestones and shales. No section of the formation has been observed anywhere which is sufficiently well exposed to permit a detailed determination of the succession of beds in the formation. The usual outcrops where not completely covered with debris from the overlying sandstone, consist of rather steep slopes with slumped slabs of limestone lying upon the surface and with occational ledges in place where gullies have been cut into it, and elsewhere locally the formation exhibits shale beds of considerable thickness, and it is the presence of these shale beds that permits the harder limestone ledges to become misplaced and to slump down the hillsides.

The limestone beds in the Golconda formation are more or less variable in character, but in general they are more or less coarsely crystalline in character and gray in color, varying from nearly white to a rather dark bluish gray. Locally some oolitic limestones occur in the formation but it has not been possible to determine the presence of any widespread, continuous, oolitic horizons, such as is present in the equivalent Lower Okaw limestone in Randolph County.

The shale beds of the Golcona formation are fully as variable in character as are the limestone. Some of these beds are more or less calcareous, others are nearly or quite free from calcareous material, and near the base of the formation especially

in eastern Pope County some beds are more or less sandy. Some shale beds are quite dark, even black in color, others are gray, and in the weathered condition at least, some beds are yellowish or buff colored. Locally, in Pope County, a shale bed distinctly red in color has been observed, but it cannot be said that any continuous, red shale horizon is present in the formation. The distribution of the shales and limestone in the formation has not been entirely established, but there seems to be a lower horizon which is more dominantly limestone, succeeded by a zone in which the shales are more fully developed, and this again succeeded by more limestone beds. The thicker and more massive limestone beds seem to be present in the upper half of the formation.

Thickness. The thickness of the Golconda formation in Pope and Johnson Counties exhibits a considerable range of variation. In the Ohio river bluffs above Golconda there is an interval of about 150 feet between the top of the Cypress and the bottom of the Hardinsburg sandstone. In Johnson County the Golconda is fully 150 feet thick in the point of the bluff near the middle of sec. 28, T. 13 S., R. 3 E. and a similar thickness, or nearly as great is present in the bluffs forming the north wall of the Cache River valley between the Big 4 and C. B. & Q. railroad tracks. In the point of the hill near the middle of the southern part of sec. 26, T. 13 S., R. 3 E., a half mile north of Berea Church, the Golconda formation is very much thinner than in the former localities mentioned. No actual exposures of the formation have been observed in the hill mentioned, but the interval between the uppermost exposed beds of the Cypress sandstone and lowest exposed beds of the Hardinsburg, where the Golconda must be situated, does not exceed 40 feet, and the limestone itself may even be thinner than this. Another locality where the actual observed thickness of the Golconda does not exceed 40 feet is in a short ravine tributary to Georges Creek, whose head is situated in NE¼ of SE¼ sec. 33, T. 13 S., R. 4 E., 2½ miles west of Reevesville. At this locality the limestone of the Golconda is well exposed in the interval between the sandstones.

This variation in thickness of the Golconda is due either to the erosion of the upper portion of the formation in places in the interval preceding the deposition of the overlying Hardinsburg sandstone, or to the river depositions of the higher beds in these localities. The evidence of the fossils, especially the distribution of the fauna with Pterotocrinus capitalis, shows that the basal portion of the formation probably constitutes one equivalent horizon across the entire region. This fossil has not been actually detected in the thinnest observed exposures of the formation, the one already mentioned situated 2½ miles west of Reevesville, but it has been found only a few miles west of this locality, where the actual thickness of the formation cannot be accurately determined.

Judging from observations extending across both Pope and Johnson Counties, the minimum thickness of the Golconda formation is limited to a distance of about six or seven miles along the belt of outcrop, extending westward from the Reevesville fault, and this minimum thickness probably does not exist through the whole of this distance, being most pronounced at the two extremities of the strip mentioned, with a greater and more nearly normal thickness between. The normal, average thickness of the formation in the two counties is probably in excess of 100 feet but somewhat less than the maximum observed thickness of 150 feet.

Stratigraphic relations. As has already been indicated, there is probably no stratigraphic break between the Golconda limestone and the underlying Cypress sandstone. In eastern Pope County, at least, there are sandy beds recurrent in the basal portion of the Golconda, in which fossil shells and bryozoans are preserved, indicating the absence of any abrupt lithologic change in passing from the lower formation to the higher. The conglomeratic layer that has been observed in one locality near the base of the Golconda, is apparently a local phenomenon which may not indicate any unconformable relation.

The actual contact between the Golconda limestone and the overlying Hardinsburg sandstone has been observed in only two localities, one in the Ohio River bluff a short distance above Golconda, in Pope County, and the other in the high bluff near the center of Sec. 28, T. 13 S., R. 3 E., about four miles south of Vienna, in Johnson County. At both of these localities there is an abrupt change from the limestone below to the sandstone, the actual contact line being more or less uneven, and the upper surface of the limestone exhibits more or less oxidation, all these phenomena suggesting the presence of an unconformity between the two formations. Added to these phenomena the fact of the varying thickness of the Golconda, with the evidence that it is the upper portion of the formation that is absent locally, doubtless due to pre-Hardinsburg erosion, the occurrence of an unconformity at the top of the Golconda formation seems to be well established.

Paleontology. The Golconda formation has been the source of large numbers of invertebrate fossils, the dominant forms being brachiopods, bryozoans and pentremites, but aside from these there are locally at least, faunules in which the molluscs occupy a large place, especially a group of small gastropods and pelecypods.

The best index fossil for the basal, or at least lower beds of the Golconda limestone is Pterotocrinus capitalis. The specimens of this species that are met with are the thickened, and rather massive "wing-plates" of the species. This genus of crinoids is a most peculiar one, having four spreading plates extending out from the ventral surface, the form of the plates exhibiting much variation in the several species of the genus. Some species have these plates spine-like in form, in others they are thin and wing-like or spatulate in form, but in P. capitalis they are much thicker and more massive and of quite a different form than in any other species of the genus. Then capitalis plates are so characteristic of the lower beds of the Golconda, that this horizon may be called the capitalis zone. The capitalis zone has been recognized

widely in southeastern Illinois and the adjacent part of Kentucky. The examples of P. capitalis are met with in many localities in Crittenden Co., Kentucky, and are not at all uncommon in Pope County, Illinois, but in a westerly direction the species becomes less common. The westernmost locality where the characteristic capitalis plates have been collected is in the Cache River bluff in Sec. 19, T. 13 S., R. 3 E., at the point where the river channel swings in against a projecting point of the bluff, and the species has been observed in only two other localities in Johnson County. The rarity of the species in collections may be due to the fact that the lower portion of the Golconda formation is commonly obscured by talus accumulations.

Another species that has to the present time proven to be restricted to the lower portion of the Golconda limestone, is Pentremites obesus. This is one of the largest, if not the largest member of this genus, and it is known to occur in a rather limited horizon, but it has not been collected in many localities and has not as yet been observed in Johnson County. The locality which has up to the present been proven to be the most prolific in this species is in the Ohio river bank, somewhat above low water mark, a little more than one mile above Golconda. The species has been collected also at the Golconda Cement plant quarry, a mile and a half west of the town, and it is known from near Homberg. Besides these localities the species have been collected by the writer in Crittenden County, Kentucky, but it is as yet unknown west of the Homberg locality mentioned.

The Golconda fauna includes many forms in which are common to the lower Chester faunas, such as an abundance of the same types of Composita trunicla and Cliothyridina sublamellosa and others, but in the Golconda these forms are associated with Camarophoria explanata, a species which is unknown in the Lower Chester faunas.

One of the most important fossil collections from the Golconda limestone in Pope or Johnson County, has been secured from near the base of the formation in

NW¼ of SE¼, Sec. 22, T. 13 S., R. 3 E., about four miles southeast of Vienna, where the following species have been recognized.

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This fauna contains a large number of rather small mollusc shells, both pelecypods and gastropods, a faunal character that is rather unusual in the Chester, and a large number of these forms, including all of the most peculiar ones are known to occur also in a fauna from the lower part of the Okaw limestone in Randolph County. In the Johnson County locality this fauna includes examples of Pterotocrinus capitalis which is not known in the Randolph County collection, but the fauna serves to tie together the lower Golconda and the lower Okaw of the two regions.

Correlation. The correlation of the lower portion of the Golconda limestone with the lower portion of the Okaw limestone of Randolph County is fully established on the evidence of the last fauna which has been mentioned, although the Pterotocrinus capitalis has not been actually found in both regions. With this correlation established, the correlation of the underlying Cypress sandstone with the much thinner Rinera sandstone in the Mississippi river section is likewise established. It is known, however, that the Okaw limestone of Randolph County does include much more than the Golconda formation, and that the upper portion of the Okaw is younger than any part of the Golconda.

Hardinsburg Sandstone

Distribution. The Hardinsburg sandstone forms the upper portion of the escarpment of which the Golconda limestone comprises the lower part of the slope, and the sandstone underlies the cuesta slope back of the escarpment. The width of the slope underlain by the Hardinsburg sandstone is somewhat less than that of the Cypress sandstone because the formation is thinner, and is in general in the neighborhood of one mile. This belt stretches across Pope and Johnson Counties, bordering the Golconda limestone belt that has been described, beginning at the Pope-Hardin county line north of the mouth of Brushy Fork, extending in a southerly direction to the Ohio river bluffs just above Golconda, and from there assuming a more westerly direction to the Brownfield fault at Brownfield. The belt is interrupted by the downdropped block between the Brownfield and Reevesville faults, but west of the Reevesville fault the belt continues in a westerly direction to the west boundary of Johnson County and passes into Union County. There is some lack of continuity of the belt of Hardinsburg sandstone west of the Reevesville fault, due to the interruption of the Wartrace fault and again by the Vienna group of faults. The wedge-shaped area of Hardinsburg ss shown southeast of New Columbia, with its pointed extremity directed in a northeast direction, is not certainly determined. As in the case of other Chester sandstones in southern Illinois, the determination has to be made through the agency of fossils found in adjacent limestones, and in the block in question a single inadequate limestone outcrop has been observed beneath the limestone which is possibly Golconda, and is certainly either Golconda or Glen Dean, the sandstone must then be either Hardinsburg or Tar Springs.

Lithologic character. The several sandstones of the Chester series in Pope and Johnson Counties are remarkably similar in lithologic character, and without some associated limestone outcrop, whose position in the section can be determined from the fossils which it contains, the sandstones themselves cannot commonly be distinguished in many places. Like the other the Hardinsburg is a fair grained, variously bedded,

brownish yellow sandstone. In general the lower portion of the formation is more massive than the higher beds, and these beds form more or less vertical cliffs in places along the Golconda-Hardinsburg escarpment. The best exhibition of Hardinsburg sandstone bluffs is perhaps along the Ohio river above Golconda for a distance of three or four miles. Some portions of the formation are evenly bedded, elsewhere cross-bedding is conspicuously developed, ripple marks and other shallow water markings are commonly present.

Thickness. Considerable variation in the thickness of the Hardinsburg is exhibited in the course of its distribution across Pope and Johnson Counties. The greatest thickness of the formation is in eastern Pope County. In the Ohio river bluffs, southeast from Rock Quarry School, two and one-half miles above Golconda, there is an interval of approximately 100 feet between the Golconda and Glen Dean limestones, the whole of which is doubtless occupied by the Hardinsburg. Further north, in the west wall of Grand Pierre Creek valley, opposite the mouth of Hobb Creek, the same interval apparently does not exceed 80 feet. In the floor of the valley tributary to Flat Lick Branch, between Old Brownfield and Brownfield, no solid rock is exposed ordinarily but the statement is made by residents of the region that at times, after flood conditions the valley floor is washed clean in places and is seen to consist of limestone. This can only be the top of the Golconda limestone, for the overlying Hardinsburg sandstone outcrops nearly down to the level of the creek. The Glen Dean limestone is exposed at an elevation of essentially 120 feet above the valley floor one half mile east of Old Brownfield, so that there is at least 100 feet of Hardinsburg sandstone in this section, with the possibility of a little excess of this thickness. West of the Reevesville fault, between Reevesville and Benton School, in Johnson County, the formation is also at least 100 feet or thicker, but two miles a little southwest of Reevesville the interval between the underlying and overlying limestone does not exceed 60 feet, and westward, across Johnson County about 60 feet is the usual thickness

of the formation. At one point, however, about 3 miles south of Vienna, in the bluff forming the north wall of a tributary to Dutchman Creek, NW¼ of NW¼ sec. 21, T. 13 S., R. 3 E., the Hardinsburg sandstone is only about 30 feet in thickness, while one half mile farther west, in the west face of the same hill there is 60 feet present, and still farther west, west of Dutchman Creek the thickness increases still more, approaching or perhaps reaching the thickness of 100 feet locally.

Stratigraphic relations. The evidence bearing on the presence of an unconformity at the base of the Hardinsburg has already been presented in connection with the discussion of the Golconda limestone. The actual line of contact between the Hardinsburg and the overlying Glen Dean limestone has nowhere been observed so that the stratigraphic relations between these two formations can only be conjectured. The fact that the Hardinsburg apparently becomes somewhat more thinly bedded in its upper portion suggests that the formation may become shaly and pass by regular gradation into the Glen Dean. On the other hand the varying thickness of the sandstone suggests that there may have been an erosion period preceding the deposition of the Glen Dean limestone, but the establishment of the true stratigraphic relations between these two formations must remain for further observations.

Paleontology. Aside from the occasional presence of a more or less imperfect trunk of Lepidodendron, and a few other imperfect fragments of plant remains, no fossils have been observed in the Hardinsburg.

Correlation. The correlation of the Hardinsburg sandstone with the Chester section elsewhere in Illinois, is dependent entirely upon the correlation of the underlying and overlying limestones with their abundant invertebrate facies. As has already been pointed out, the Golconda ls is definitely correlated with the lower protion of the Okaw limestone of Randolph County. The upper part of the Okaw limestone is likewise correlated with the Glen Dean limestone, consequently the Hardinsburg must be the equivalent of some part of the Okaw formation. If a number of sections of the Okaw

limestone were Chester, Illinois, there is a thin sandstone member which occupies a position just beneath these beds that are equivalent to the Glen Dean. These sandy beds, therefore, occupy the position of the Hardinsburg sandstone and they may be considered as being the northwestern extension of the Hardinsburg, much reduced in thickness from the usual development of the formation in Johnson, Pope and Hardin Counties.

Glen Dean Limestone

Distribution. The distribution of the Glen Dean limestone in Pope and Johnson Counties is in general along a narrow belt subparallel with the belt of Golconda limestone that has already been described. In eastern Pope county the belt follows a southerly course from the point where it enters the county from Hardin, to the Ohio river bluffs between Golconda and the mouth of Grand Pierre Creek. From here it takes a more westerly course to the Brownfield fault, where it is interrupted by the downdropped block between this fault and the Reevesville fault. West of the Reevesville fault the outcrop is again present continuing across Johnson County and into Union County. The continuity of this belt of outcrop is more or less interrupted in places by the faults which cross the two counties, besides the complete interruption by the broad downdropped block mentioned above. Throughout much of its belt of outcrop the Glen Dean occupies the lower portion of an escarpment in which the overlying Tar Springs sandstone constitutes the higher portion. In only a few places throughout its whole extent is the Glen Dean outcrop more than one-fourth of a mile in width, and through much of its extent it is even narrower than this.

In some parts of its course this Glen Dean outcrop is wholly covered by surficial deposits, the presence of the formation being indicated by a line of sinkholes. Under such conditions it is, of course, not possible to draw the boundary lines of the formation upon the map with entire certainty.

Lithologic characters. The Glen Dean formation is constituted of limestone and shale. In some sections the shale predominates, elsewhere the limestone beds constitute an important part. This different appearance of the formation in different places is perhaps dependent upon which portion of the formation is exposed, for in general it can be said that the lower portion of the formation is dominantly shaly, while the higher part contains more limestone. As in the case of other limestone and shale formations of the Chester series it is not possible to work out the details of

the succession of beds in the formation because of the surficial covering of talus which is invariably present upon the lower slopes of the Glen Dean Tar Springs escarpment along which the outcropping belt of the formation is situated.

The limestone beds of the Glen Dean formation, as they occur in Pope and Johnson Counties, resemble those of the Golconda. They are in general more or less crystalline, and dark or light gray in color. In places certain limestone beds of the formation are compact and dense in texture, showing little or no crystalline structure. The individual beds of limestone are of moderate thickness, commonly not exceeding a foot or two and in places even thinner, with shaly seams parting the beds. No oolitic beds have been noticed in either Pope or Johnson Counties, but such beds are present in some parts of Hardin County, and may be looked for farther west. The Glen Dean limestones have some chert associated with them in the form of their platy masses from one to three inches thick, commonly of a rather dark chocolate color. The upper and lower surfaces of the platy chert masses are commonly somewhat decomposed for a thickness of a fraction of an inch, the decomposed portion being distinctly lighter in color than the central portion. The layers fracture vertically with more or less subcubical fragments which may be recognized in many places in the residue where no actual exposure of the limestone is present.

The shales of the Glen Dean are more or less variable in character, some being notably calcareous while other beds are quite free from calcareous material. None of the beds are notably sandy except possibly near the very base of the formations. The color of the shale beds is dark in most places, some exposures being nearly or quite black, others with a bluish cast, and in places slightly greenish. The weathered exposures the color of the shales is commonly lighter, being yellowish or buff colored in many places. The more calcareous shale beds commonly bear more or less well preserved fossils, and in places afford excellent specimens.

One of the best exposures of shale in the Glen Park formation may be seen in the public road from Vienna to Grantsburg, about three miles east of Vienna. In this outcrop nearly 40 feet of shales are exposed with only a few limestone slabs near the base of the hill, but a quarter of a mile south along the same outcrop there are better exposures of limestone with characteristic Glen Dean fossils. The limestones of the formation are very well exhibited in the southern portion of the isolated, subelliptical hill rising from the bottoms of Johnson Creek in the southern half of sec. 16, T. 13 S., R. 4 E., a mile and one half southwest of Grantsburg. A very good exhibition of both shale and limestone beds in the formation may be seen in the exposure along the C. B. & Q. railroad in NE¼ of SW¼ sec. 3, T. 13 S., R. 2 E., about a mile south of West Vienna.

Thickness. The thickness of the Glen Dean formation in Pope and Johnson Counties exhibits considerable variation, and this variation seems to be dependent upon the presence or absence of the higher beds of the formation. In the shale exposures along the public highway three miles east of Vienna, already mentioned, the thickness of the formation can be very little if at all greater than 40 feet, but at this place the shale beds of the lower portion of the formation above are exposed, these being followed at once by the lower sandstone beds of the Tar Springs. On the other hand in the bluff in east ¼ of NE¼ sec. 21, T. 13 S., R. 3 E., three miles south of Vienna, there are at least 72 feet of Glen Dean in which much limestone is present, and a little further along the same bluff to the west there is at least 60 feet of the same formation. The occurrences mentioned probably represent about the minimum and maximum thicknesses of the formation, and the average thickness is probably about 60 feet. In most localities where an approximation of the thickness can be made, there is an interval of about 60 feet between the highest exposures of Hardinsburg sandstone and the highest exposure of limestone of the lowest exposure of the Tar Springs ss, but the localities

where any approximately accurate determination of the thickness can be made are few.

Stratigraphic relations. Because of the imperfect exposures of the formation, the contacts of the Glen Dean with neither the underlying Hardinsburg nor the overlying Tar Springs sandstone have been seen, and the structural relations between the Glen Dean and the adjoing formations above and below can only be conjectured. From the fact that the underlying Hardinsburg sandstone seems to become more thinly bedded towards the top, passing into a shaly condition, associating with the known dominance of shales in the lower portion of the Glen Dean, suggests that there was a continuity of sedimentation from one formation to the other with no stratigraphic break.

The most significant fact in regard to the stratigraphic relations of the Glen Dean with the overlying Tar Springs, is the varying thickness of the Glen Dean which may be due to the presence of an erosion interval preceding the Tar Springs, in which case the two formations would be separated by an unconformity.

Paleontology. In common with the other limestones of the Chester series, the Glen Dean contains numerous fossils in many places. The limestone indeed is made up wholly of fragmental organic material, but much of it is too imperfect, or too firmly imbedded in the limestone to permit its proper identification. Among the collections made from this formation in Pope and Johnson Counties, the following ones may be especially mentioned.

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Among the fossil species which are most persistently present in the Glen Dean fauna, the bryozoan Prismopora serratula may be especially mentioned. This species is not restricted to the Glen Dean, it has been observed rarely in the Golconda, and the same or a closely allied species has been collected in one locality in the Paint Creek. It is also present in the Vienna limestone, higher up in the section than the Glen Dean. It is in the Glen Dean, however, that this species

flourishes most conspicuously. In almost every locality where fossils can be found in any numbers at all, this species can be detected, and in places there are veritable Prismopora gardens exhibited upon some of the exposed surfaces of the limestone. A number of other bryozoans are also highly characteristic of the Glen Dean horizon, among which may be mentioned Stenopora ramira and Archimedes loxa.

Another fossil form which is characteristic of the Glen Dean, and which has as yet been observed only in this formation, is Pentremites spicatus. This is a larger species of the genus, but not so large as P. obesus of the Golconda, it has long deeply V shaped ambulacra in cross section with the extremities of the deltoid plates rising conspicuously above the oral surface. This species is not so commonly met with in the collections as is Prismopora, but it does occur somewhat commonly in certain localities, and may be looked for wherever good exposures of the Glen Dean occur.

Many of the species in the Glen Dean faunas are common to other horizons of the Chester, both lower and higher in the series, but the representatives of the genera Spirifer, Composita and Cliothyridina are much more nearly like those of the lower horizons than those which occur above the Glen Dean.

Correlation. In searching for the correlations of the Glen Dean formation in the Randolph County section of the Chester series, it is found that the faunal characteristices of the formation are duplicated in the higher beds of the Okaw limestone which have been called the Plum Creek beds in that County. The common faunal characteristics of the beds in the two regions, associated with the similar stratigraphic position, where the absence or near absence of the Hardinsburg ss in Randolph County is taken into consideration, makes the correlation of the Glen Dean with the upper division of the Okaw limestone an assured fact.

Tar Springs Sandstone

Distribution. The belt of outcrop of the Tar Springs sandstone across Pope and Johnson Counties varies from less than one to more than two miles in width, and is continuous except where it is interrupted by the deeply downdropped block between the Brownfield and Reevesville faults. Aside from the complete interruption just mentioned, there is some offsetting of the belt at a number of places of other faults which cross the region, the greatest irregularity being in southeastern Johnson County a little west of Reevesville, this disturbance in the distribution of the outcrop being due to the dislocation along the northwest-southeast Wartrace fault. The belt occupied by the formation enters Pope County from Hardin County on the east, near the northeastern corner of the county. From here the belt extends in a southerly direction towards Golconda, but nowhere approaches sufficiently near to the Ohio river to take part in the immediate river bluffs. North of Golconda the outcrop of Tar Springs swings more to the west to the intersection of the belt with the downdropped fault block already mentioned. West of this downdropped block the outcrop again appears, directly opposite outcropping belt to the east from here it continues to the western boundary of Johnson County in a direction slightly south of west, or parallel with the outcropping belts of the older Chester formations.

A little over two miles east of Vienna the Tar Springs sandstone occupies a wedge-shaped area bordered on both east and west sides by faults which extend considerably to the north of the outcropping belt either to the east or to the west. This distribution of the surface outcrop of the formation is due to the downdropping of the fault blocks on either side.

Throughout its whole extent, except where conditions have been locally disturbed by faulting, the outcropping belt of the Tar Springs is a gentle cuesta slope with its higher margin to the north or west, and limited to the south and east by the more or less abrupt Glen Dean-Tar Springs escarpment.

Lithologic character. As it appears in surface exposures the Tar Springs sandstone exhibits considerable variation in lithologic character. In places the formation is massive and rather thick bedded, and elsewhere it is conspicuously thin bedded. The layers exhibit much crossbedding, and the thinner bedded parts especially are much ripple marked. The formation also includes a rather conspicuous shale bed, the shale being dark, or a rather light gray with a slight yellowish or pinkish tint, a good exposure of this shale may be seen about one mile west of Vienna, by the roadside in NW¼ of SE¼ sec. 6, T. 13 S., R. 3 E. At this locality a thin sea of carbonaceous or coaly material two or three inches thick is present, and this coal horizon seems to be a persistent feature of the Tar Springs shale bed and has been recognized at a number of points in Johnson County and is known about as far east as Hardin County. Another good exhibition of the shale member of the Tar Springsis in the west bank of Bay Creek at Grantsburg the shale at this locality being quite dark in color.

The color of the Tar Springs sandstone in Pope and Johnson counties is in general somewhat darker than the Hardinsburg or Cypress sandstones, the surface exposures as seen in the roads and stream valleys commonly having a distinctly reddish brown color, rather than the paler yellowish brown of the earlier formations. In many places, however, outcropping ledges of the Tar Springs are quite like similar outcrops of any of the other sandstone formations of the Chester series, in fact the several sandstone formations of the Chester series in Illinois are so much alike in many of their outcrops that it is entirely impossible to distinguish them except as their relation to fossiliferous limestone formation is known.

Thickness. The Tar Springs sandstones exhibits considerable variation, the thickness apparently diminishing somewhat to the west. In eastern Pope County the formation has a thickness of 100 feet or more, probably as much as 150 feet in places, but in Johnson County this formation probably nowhere attains a thickness of 100 feet,

and in places may be as little as 40 feet, although its average thickness in that county is probably in the neighborhood of 80 feet. The thinnest exhibition of the formation that has come under observation is in NE¼ sec. 18, T. 13 S., R. 4 E., three and one-half miles west of Grantsburg, where the interval between the underlying Glen Dean and the overlying Vienna lime does not exceed 40 feet. In the western part of Johnson County the thickness seems to be from 60 to 80 feet.

Stratigraphic relations. There is no certain knowledge of the exact line of contact between the Tar Springs sandstone and either the underlying Glen Dean or the overlying Vienna limestone, so that the stratigraphic relations of the formation can only be inferred. As has been pointed out earlier, the variation in thickness of the underlying Glen Dean formation suggests the possibility of an erosion interval preceding the deposition of the Tar Springs sandstone, but the presence of such a stratigraphic break and unconformity has not been demonstrated with certainty. There is even less evidence bearing on the stratigraphic relations with the Vienna limestone.

Paleontology. The only fossils know in the Tar Springs sandstone in Pope and Johnson Counties are imperfect fragments of plant stems, among which Lepidodendron may be recognized. In Hardin County a collection of well preserved ferns and other plants has been collected at one locality in a shale which is probably Tar Springs, but no such flora has yet been found in the more western counties, though it should be looked for and may be found at some future time.

Correlation. The correlation of the Tar Springs sandstone with the formations in the Chester series of Randolph County, is dependent entirely upon the correlation of the underlying and overlying limestones. The correlation of the Glen Dean limestone with the upper beds of the Okaw limestone places the Tar Springs above the Okaw. In the Randolph County section the Okaw is succeeded by the Menard limestone, which in

Pope and Johnson Counties lies well above the Tar Springs sandstone. This being the situation, it then becomes evident that the Tar Springs sandstone occupies a position in the section that is represented in Randolph County by a break in the sedimentation and an unconformity. Unlike the horizon of the Hardinsburg sandstone, where there are sandstone beds at least locally in Randolph County, the horizon of the Tar Springs is totally wanting in any sand deposition, so far as observations have been made up to the present time.

Vienna limestone

Distribution. The Vienna limestone is named from Vienna in Johnson County, where it is exposed west of the public square in the town, along the two streets which lead to the West Vienna, and the Cypress Roads. The formation is also well exposed in an old quarry situated in the end of the hill just west of there, south of the West Vienna road, in NW¼ sec. 5, T. 13 S., R. 3 E. Much of the way from Vienna to Mount Pleasant the public road in east Union County is upon the Vienna limestone, and exposures of the formation may be seen at a number of localities. East of Vienna from the Vienna limestone belt is considerably interrupted for three or four miles, but from the NW¼ of sec. 13, T. 13 S., R. 3 E. to the Wartrace fault the belt is continuous and with a very slight interruption at this fault it is continuous to the Reevesville fault which forms the western border of the deeply downdropped Dixon Springs fault block. East of the Brownfield fault the Vienna limestone belt is again present in the section passing just south of Waltersburg, and continues with only slight interruption by faulting nearly to the eastern edge of Pope County. The easternmost good exhibition of the formation is along the lower slope of the bluff below Grandview school, in SE¼ sec. 8, T. 12 S., R. 7 E. The formation has not been differentiated from the Menard limestone in Hardin County, because of the absence from the section in that county of the Waltersburg sandstone, but it is altogether probable the beds equivalent to the Vienna are present in that county.

Lithologic character. The Vienna limestone is represented by two rather distinct types of lithology. In its typical expression it is an exceedingly siliceous limestone which on weathering passes into a yellowish or light brown porous rock which at first sight might pass for a sandstone. The outcrops commonly met with along the road from Vienna to Pleasant Hill consist of loose masses of this porous rock. Associated with these beds in places there are conspicuous chert layers which are quite different from the porous brown siliceous rock that has been mentioned. These chert layers are commonly two or three inches thick and when seen in place in the limestone

are more or less continuous. The inner portions of the chert are dark in color, commonly chocolate brown, but in the weathered condition the outer surfaces, where the layers are in contact or have been in contact with the enclosing limestone, are weathered to a much lighter color to the depth of a fraction of an inch. These chert masses fracture vertically into subcubical blocks of various sizes which are a conspicuous characteristic of the residue from the Vienna limestone in many localities. In places more or less porous chert masses eight or ten inches in thickness occur in the residue. The limestone layers which are associated with the chert and other siliceous beds mentioned above more or less resemble other Chester limestones. They are commonly not so conspicuously crystalline as are the Glen Dean and Golconda limestones, but are likely to be less dense and compact in structure than the Menard limestone.

A second type of lithology exhibited by the Vienna formation is the dark shales. In places these black or dark bluish shales constitute a large portion of the formation, elsewhere they are much less conspicuous. Where both types of lithology are present in the same section the limestones are below and the shales above, but in places the shales may be nearly or quite wanting and elsewhere they constitute the greater part of the formation.

One of the best exhibitions of the Vienna formation where both limestones and shales are present, is in the small valley running to the south in SE¼ of SE¼ sec. 2, and NE¼ NE¼ sec. 11, T. 13 S., R. 6 E. three and one half miles north of Golconda. At this place the following section through the Vienna Waltersburg and Menard formations are exhibited.

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(see p. 175 - Hardin Co. ms.)

In the gutters by the public road side just east of the section just described may be seen quantities of the characteristic chert fragments which are so commonly met with in the residue over the outcrops of the Vienna limestone.

In the short ravine just southeast of Waltersburg in Pope County, and also to the east of the same place, good exposures of the limestone of the Vienna formation can be seen. The shales are not so well shown here, but they may be present though obscured by surficial accumulations. Along the road west from Waltersville, the characteristic Vienna chert is in evidence going down the hill a little over one-fourth mile from the store at the road corner.

West of the Reevesville fault the Vienna limestone is more generally represented by the siliceous limestone facies of the formation. The brown, porous, siliceous material resultant from the weathering of the bed is met with commonly along the roads and on hillsides even in cultivated fields where this formation is the underlying formation, but the shale is commonly either absent or obscured by surficial material. Upon the hill slope on the road from Grantsburg to Vienna, one mile west of the former place, much of the characteristic residual Vienna chert is scattered, and the upper portion of the slope, beneath the overlying sandstone, without outcrops of any sort, is probably underlain by shales. Low bluffs of the Vienna limestone with its characteristic chert beds, are well exhibited along northwest side of the stream tributary to Dutchman Creek just east of Vienna, north of the road to Grantsburg, two miles east of Vienna. Nowhere in the entire area of Pope and Johnson Counties is the porous, yellow residual product of weathering of the Vienna better exhibited than in the public road on the hill just west of Fairview Church, two miles southeast of Vienna. At this point there are fifty feet or more of this material in its original bedded condition, with no shale beds above it, although the absence of the shale at this place may be due to the presence of the north-south fault which passes close to Fairview Church.

West of Vienna, both the shale and the siliceous limestone facies of the formation are well exhibited. The shale is well exposed in the public road above comparatively thin beds of the siliceous limestone, as indicated by the residue, in the hill one mile east of West Vienna, in the south $\frac{1}{2}$ of sec. 35, T. 13 S., R. 2 E.,

and the brown porous, siliceous residue of the limestone is well exposed on a number of hill slopes in the road from West Vienna to Pleasant Hill.

Thickness. The most satisfactory section for measuring the thickness of the Vienna is the one three and one-half miles north of Golconda, already mentioned, where the limestone and shale together have a thickness of about 70 feet. The sandy beds at the top which are included in this thickness doubtless represent the Waltersburg sandstone, and to that extent the thickness would be reduced, but on the other hand the very base of the limestone is not exposed, and the amount of thickness to be reserved from the top would doubtless be added at the base. In places in the region under discussion, the interval to be alloted to the Vienna apparently does not exceed 40 feet elsewhere it is 60 feet or thereabouts. From this it will be seen that the observed thickness of the formation varies between 40 and 70 feet, and about 60 feet may be taken as the average for the formation across the two counties under consideration.

Stratigraphic relations. The stratigraphic relations of the Vienna formation with the underlying Tar Springs sandstone have already been mentioned. The presence of any stratigraphic break or unconformity cannot be demonstrated and probably does not exist. The actual contact between the Vienna and the overlying Waltersburg sandstone has nowhere been obscured where the higher formation is strongly developed. In the Vienna-Menard section which has been given in an earlier page, the sandy beds at the summit of bed No. 2 doubtless represent the Waltersburg sandstone. They are more than five or ten feet in thickness at the outside and a complete gradation from this into the underlying shales may be seen, which suggests continuous sedimentation from one formation into the other, and absence of any relations of unconformity.

Paleontology. The fossils of the Vienna limestone are similar in a general way to those of the other Chester limestones. The fauna is composed of brachiopods and bryozoans for the most part with a few representatives of other groups, chiefly

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the molluscs. The brachiopods and bryozoans are members of the same ~~species~~ genera as those in both the older and younger, but the association of forms is peculiar to this horizon in some respects, and exhibits features which are somewhat intermediate between the faunas of the older Glen Dean and the younger Menard formations. This intermediate character of the fauna is shown in the association of the bryozoan Prismopora serrulata with the pelecypod Sulcatopinna missouriensis. The Prismopora occurs more commonly in the limestone than anywhere else in the Chester series outside of the Glen Dean, and the highly characteristic Sulcatopinna of the Menard has been collected at a number of localities and may be considered as being a fairly common member of the fauna. No fossils have been found in the shales.

The list of some of the faunules which have been collected in the Vienna limestone are as follows.

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Correlation. In considering the correlatives of the Vienna formation in the Chester sections of Illinois outside of Pope and Johnson Counties, the thinning out of the overlying Waltersburg to the east and west, as will be described later, must be taken into consideration. In Hardin County, east of where the Waltersburg sandstone is developed or dark shale layer has been recognized, at the bottom of the Menard limestone. This shale has been considered, and has been mapped in that county as a part of the Menard, but it is altogether probable that it is really an eastward extension of the shale facies of the Vienna. Likewise in Randolph County, at a number of localities, there is an important black shale bed beneath the more typical Menard limestone and overlying the Okaw limestone. In this section both the Tar Springs sandstone and the Waltersburg sandstone are wanting, and the shale occupies exactly the same stratigraphic position relative to the upper Okaw (Glen Dean) and the Menard, that the Vienna occupies, and inasmuch as the Vienna itself is constituted largely of a similar black shale in many places, it is not unreasonable to conclude that the

shale in Randolph County is really an extension of and an equivalent of the Vienna formation in the more southern counties of Illinois.

Waltersburg Sandstone

Distribution. The conspicuous development of the Waltersburg sandstone is confined entirely to Pope and Johnson Counties. Passing to the east into Hardin County the formation disappears from the section, and in the western part of Johnson County it is much reduced in thickness and becomes and inconspicuous unit in the section. — The maximum development of the formation is east and west of Bay Creek a little north of Grantsburg. Northwest of Grantsburg, east of the Wartrace fault the width of outcrop of the Waltersburg is nearly two miles, where it occupies the gentle cuesta slope between Vienna and Menard escarpments. Along the southern side of the valley tributary to Bay Creek from the west across the south half of sections 3 and 4, T. 13 S., R. 4 E., the Waltersburg rises, as a nearly vertical cliff, and both sides of the Bay Creek valley where it is so narrow in the southern half of this same section 3 is limited by abrupt cliffs of this sandstone.

East from these Bay Creek exposures of the Waltersburg sandstone, the formation is well developed to the Reevesville fault. The outcrop is interrupted by the downdropped block between the Reevesville and Brownfield faults, but reappears at Waltersburg, east of the last named fault. Good exposures of the sandstone are present in the public road just out of Waltersburg to the north, and it is from these exposures that the formation has been named. In passing to the east the formation becomes less conspicuous. Three and one-half miles north of Golconda, in the section which has been recorded on an earlier page it is represented by only a few feet, perhaps five or ten, of sandy beds between the black shale of the Vienna ls and the Menard limestone. Just south of Gowinsville it is developed in about the same degree, and exposures of it are present at a number of points south of Gowinsville on the road to Golconda. In the lower portion of the bluff below the Grandview School in the SE$\frac{1}{4}$ of sec. 8, T. 12 S., R. 7 E. the Waltersville is present, and it constitutes the greater portion of the ridge whose south end extends into the NE$\frac{1}{4}$ of the same sec. 8. In the extension of the Chester section into Hardin County the Waltersburg sandstone has not been observed.

West of the conspicuous Bay Creek cliff exposures of the Waltersburg sandstone the formation underlies a rather broad belt. The sandstones exposed along the road north from Wartrace belong in this formation. West of the Wartrace fault the Waltersburg underlies much of sections 8 and 7, T. 13 S., R. 4 E., and sec. 12, T. 13 S., R. 3 E., and in parts of this area, in the ravines leading to the north, and along the road between sections 7 and 12, the massive character of the formations can be observed. West of this area the outcropping belt of the formation is interrupted by faulting, and the next notable exposures are in Vienna upon the northern slope of the hill occupied by the town, towards the fairgrounds. West of Vienna the formation becomes inconspicuous, as compared with the exposures north of Grantsburg, although it can be recognized at a number of points in the road between Vienna and West Vienna, and also west of the latter place.

Lithologic character. The Waltersburg Sandstone resembles the other sandstones of the Chester series, and isolated outcrops of the formation, unassociated with any limestone formation cannot be distinguished. The formation exhibits considerable variation in its different exposures, and is quite different in appearance where it is thin from where it is developed as a thick sandmud. In its thicker part, east and west of Bay Creek, it is a very massive sandstone, the cliffs standing essentially vertical in position, the massiveness of the beds being more nearly like that of the Cypress Sandstone than any other in the Chester Series of this region. Its color is light brown, like most of the other sandstones, but in places quite widely separated geographically, there are beds with a decided pink tint. The sandstone is fine in texture, quite similar to the other formations of the series. Where the thickness of the formation is much reduced, as it is east of Waltersburg or west of Vienna, the layers are thin, not more than two or three inches, and in many places they exhibit a tendency to break along two sets of points, one set much more closely

placed than the other, into elongate, sliver-like rhomboidal masses two to four inches in width and thickness, and a foot or more in length. These sliver-like fragments are well shown in the measured section of the Vienna and Menard formations which is given on page --, and again along the road south of Gowinsville, and elsewhere in Pope County. The same character is exhibited in the thinner Waltersburg sandstone west of Vienna. In places these thin, splintery beds are rather darker brown in color than the more massive beds, and locally at least are slightly olive green in color.

Thickness. Where the Waltersburg sandstone has its greatest thickness north of Grantsburg it attains a thickness of not less than 60 feet, and probably as much as 70 feet. From this maximum thickness it thins out to nothing to the east, in Hardin County, and is reduced almost if not quite to zero at the west boundary of Johnson County.

Stratigraphic Relations. In the section three and one half miles north of Golconda which has been described on page --, the Waltersburg sandstone is represented by the few feet of the sandstone at the top of the black shales. The shales pass into the sandy beds by a complete gradational change and there is no reason to assume any condition other than contour sedimentation from the lower bed to the upper, and consequently an absence of any relation of unconformity. So far as can be judged there is also an absence of any evidence to show that there was any break in the sedimentation above the sandy beds in the same section.

In no section where the sandstone is present in its maximum development, have either of the contacts been observed, but there is no reason to suppose that the stratigraphic relations are different in those situations from where the formation is thin. The occurrence of such an important sandstone unit in the Chester series, with its limited extent in an east west direction, at least as a thick formation, arouses interest in the question of the origin of the sand. All of the Chester sands were of course transported by streams, and were carried from the land surface and deposited in the sea. In the case of these sandstones which are widely distributed

it is not practicable to localize the source of the constituent material, but in the case of the Waltersburg whose extent east and west as a thick formation is less than a score of miles, the source of the materials can be more closely localized. The Chester Embayment in which southern Illinois is situated, doubtless connected with the open sea to the south. The land surface which drained into the basin lay to the north, but the land of Ozarkia lay to the west at some considerable distance, and Cincinatia to the east. The stream or streams which transported the Waltersburg sand, however, could not have entered the embayment from either the east or the west, for the sands decrease notably in thickness in both of these directions. This leaves only the north as a possible source of the material. It is known from deep well records that the Chester sediments extend as far north in Illinois, beneath the Pennsylvanian sediments, as a point near Decatur; from this point the shore line swung away to the southwest and to the southeast. This shore line did not remain persistently in one place during Chester time. This presence of undoubted unconformities in the southern Illinois section demonstrates that at times Pope and Johnson Counties were dry land, and that the shore line lay south of this region, perhaps beyond the limits of the state of Illinois, and in the actual succession of events during this period of time, the shoreline doubtless shifted back and forth between a more northern and a more southern position several times during the Chester. In the pre-Chester formations of Illinois and the north, which might have been exposed as the surface formations during this Chester time in the great land surfaces which stretched to the north from the Chester Sea, there is very little sandstone which could have given origin to the Chester sands, except far to the north, at least as far away as Wisconsin. It is not improbable that streams rising far to the north may have carried some of the sands into the Chester fan that are now present in the sandstones of the series. The Aux Vases sandstones may have originated from sand brought down from Ozarkia, but some of the higher sandstones are entirely wanting in the section nearest to the Ozarkian

shore. Some of the more widely distributed of the sandstones, formations which have been recognized far beyond the confines of southern Illinois, may have been made up of sands which were transported along the shores of the Chester series for very long distances by wave action, and their original source may have been a land as far away as Appalachia to the east.

The Waltersburg sandstone, however, could not have been brought from the east, either by stream or wave agency, because the formation thins out to nothing in that direction. Neither could it have come from the west. Its northern source may be assured, and it is not at all unlikely that it was derived from some earlier Chester sandstone which had become exposed by the southward shifting of the shore line beyond the line occupied by the shoreline of the basin where the earlier sandstone was being deposited. It is even possible that more than one of the older Chester sandstones may have furnished material to be redeposited in the Waltersburg.

Paleontology. As in the other Chester sandstones, fossils are not common in the Waltersburg. A few plant remains are met with in places. Trunks of Lepidodendron are the commonest form.

Correlation. The interval represented by the Waltersburg sandstone in Pope and Johnson Counties is either occupied by continuous sedimentation of shales and limestone in Randolph County, or is represented by a period of nonsedimentation beneath the Menard limestone. At any rate there is no sandstone present in the Randolph County Section in the position occupied by the Waltersburg in the southern counties.

Menard Limestone

Distribution. The Menard limestone occupies a belt that is essentially continuous across Pope and Johnson counties except where it is interrupted by the downdropped Dixon Springs fault block. Aside from this complete interruption of the belt there are also a number of minor offsets and slight interruptionsdue to faulting. The belt varies from a quarter of a mile or less in width to somewhat more than one mile, the greater width being in Johnson County. The direction of the Menard belt is subparallel with other formations that have been described but because of the less thickness of the overlying sandstone formation and the more thinly bedded and less dense sandstone the Menard is not marked so continuously by a distinct escarpment as are some of the lower limestone formations, notably the Golconda and Glen Dean, although in places there is a distinct escarpment with the Menard limestone forming the lower slope, capped by the Palestine sandstone.

Beyond Pope and Johnson counties, the Menard limestone continues to the northwest to Randolph County, although the outcropping belt is interrupted for a considerable distance across southwestern Jackson County, and the character of the formation, both lithologic and faunal remains essentially uniform to the end of its outcrop in Randolph County. East of Pope County the Menard continues across Hardin County, and it is also widely distributed south of the Ohio River in Kentucky. Menard Limestone in downdropped block west of Brownfield and south of Bay bottoms.

Lithologic character. Like the other limestone formations of the Chester series, the Menard includes a notable amount of shale. This is especially true for the upper portion of the formation. The limestone itself, however, differs considerably in character from that of the older formations of the series. For the most part it is a hard, dense, compact limestone, breaking with a conchoidal or splintering fracture. The limestone beds contain some chert, but they are notably less cherty or siliceous than the Vienna limestone, while the Glen Dean and older formations rarely contain any chert at all. The weathered surfaces of the Menard are commonly smooth

and light gray or bluish gray in color, but the limestone is darker upon fractured surfaces, in some places being nearly black. The bedding of the limestone is very regular, the individual strata commonly being a foot or somewhat less in thickness, with no thick massive beds such as are present in some of the formations. The individual beds of limestone are separated by shaly seams, and the surfaces of the bedding planes seem to be more or less hummocky in contour. Occasional limestone beds in the formation are more crystalline than would be indicative of the description just given, but these crystalline beds are much less commonly met with than the dense and compact layers.

The shales of the formation vary in character from completely argillaceous to somewhat calcareous. The more calcareous layers in places include some thin, platy layers of limestone, which are likely to be more fossiliferous than the thicker and denser beds. The thickness of the shale beds range from an inch or less between some of the limestone layers, to beds ten or more feet thick in the higher part of the formation, where the shales seem to predominate over the limestone locally at least. At the base of the formation, very generally across the two counties, there is a calcareous shale bed ten feet or more in thickness which includes more thin limestone layers than usual, and which is unusually fossiliferous. This zone has been recognized at intervals from eastern Pope County across Johnson and into Union County.

At the bottom of the Menard formation, essentially at the contact between this limestone and the underlying Waltersburg sandstone, there is a thin, impure, coal seam two or three inches in thickness. It seems to be a persistent layer, as it has been observed at a number of localities in both Pope and Johnson Counties.

Thickness. In the measured section which has been recorded on page --, there are 95 feet of strata referable to the Menard limestone, and with the dip of the beds at that locality the thickness would be somewhat greater, one hundred feet would be a fair estimate. Four miles east of Vienna, on the Grantsburg road, the Menard is again exhibited with a thickness of approximately 100 feet. At still another locality,

just north of West Vienna, a thickness of approximately 100 feet of Menard is present, so that it can safely be concluded that the thickness is approximately 100 feet. There are places in the two counties where the formation seems to be somewhat thinner than 100 feet, but so far as observations have been made, there is no evidence for considering the limestone to exceed the thickness mentioned.

Stratigraphic relations. As has been pointed out earlier in this respect, there is no evidence to establish a relation of unconformity between the Waltersburg sandstone and the overlying Menard limestone. The great variation in thickness of the Waltersburg is due not to erosion where the formation is thin, but more probably to the fact that it was never deposited in great thickness except in a comparatively narrow area east and west, in Pope and Johnson Counties.

At no locality in the two counties under consideration has the upper contact of the Menard limestone, with the overlying Palestine sandstone, been seen. This contact has been observed in Randolph County, however, where there is a perfectly abrupt change from the underlying limestone into the sandstone above, the conditions being such as to suggest the presence of an unconformity between the two formations. The presence of such an unconformity in Randolph County makes it probable that the same conditions obtain in Pope and Johnson Counties.

Paleontology. Fossils occur throughout the Menard formation, although they are somewhat scarce and difficult to collect in good conditions in many of the more dense and compact beds of limestone. The most prolific faunas occur in the basal portion of the formation, in a layer of calcareous shales with thinly bedded limestone layers. This horizon with its characteristic fauna has been observed in the section from eastern Pope County, to western Johnson County, and even beyond into Union County. One of the best collections from this zone has been secured from a locality 3½ miles north of Golconda, the locality of the section described on page --. The following species have been identified from this place.

* * * * * *

60

(insert last of the collections)

The collections from the more dense and compact layers of limestone contain a smaller number of species than has been recognized in the fauna just described.

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(List faunas from limestone beds)

On the whole the Menard limestone fauna is very well characterized by the presence of the pelecypod Sulcatopinna missouriensis, although this species is known to occur not uncommonly in the higher limstone formations of the Chester series. It has also been observed at a number of localities in the Vienna limestone, and at one locality only in the Glen Dean. The basal zone of the Menard is especially characterized by the presence of the large pentremite, P. fohsi. This species does not grow so large as the P. obesus of the Golconda, its size being more nearly that of P. spicatus of the Glen Dean, although the two species are quite unlike. This species has been collected in every locality of the basal zone of the Menard where any considerable search for fossils has been made, and it has not been observed at any other horizon. It is uniformly associated with very large flat discoid wing-plates of a species of Pterotocrinus, which has been named P. menardensis, and like the species of Pentremites these Pterotocrinus plates are entirely confined to this zone so far as observations have been made.

One of the notable characteristics of the fauna is the decided change that is exhibited by the Spirifers and Compositas of the fauna. These genera are represented by an abundance of individuals in most of the Chester faunas, but in the formations beneath the Menard, both genera are represented by forms that are comparatively small, while in the Menard the representatives of both genera are decidedly larger and coarser in appearance.

Correlation. There are no questions involved in the correlation of the Menard limestone across southern Illinois. The formation has been mapped across Hardin, Pope and Johnson Counties and has been followed in a general way across Union. There is a gap in the outcrop of the formation on both sides of Big Muddy River, in Jackson County, but it comes to the surface again in southwestern Jackson and continues to the end of its outcrop in Randolph County. It is clearly the same horizon from end to end of this belt, with uniform lithologic and paleontologic characters.

Palestine Sandstone

Distribution. The Palestine is the first of the sandstones in the Chester series which is present in its full development in the sections of both the more southern counties of Illinois, and in the Mississippi valley section of Randolph County. The formation was first recognized, described, and mapped in Randolph County, later it was recognized in Pope and Hardin Counties, and has been mapped across these and Johnson County. The outcropping belt of Palestine sandstone across Pope and Johnson counties varies from one fourth of a mile or less, to more than a mile. The greatest width is in Pope County and the eastern edge of Johnson County extending east from Bay Creek to the Reevesville fault. The belt is subparallel with that of the underlying Menard limestone, with a southwesterly direction from near the northeastern corner of Pope County to the Brownfield fault north of Waltersburg. The Palestine is the first of the Chester formations that has a nearly continuous outcrop across the downdropped Dixon Springs fault block, although it is considerably interrupted by the faults which cut up this block. As would be expected from the general dip of the structure to the north, the positions of the outcropping areas of Palestine in the Dixon Springs block are offset considerably to the south, with one considerable area of the sandstone south of the Bay bottoms and across the line in Massac County. West of the Reevesville fault, the outcropping belt of Palestine starts in sections 9 and 10, T. 12 S., R. 6 E., two and one-half miles southeast of Eddyville. It parallels the fault line for a distance of about six miles and swings wide to the west and continues in that direction across Johnson County with only slight interruption.

Lithologic character. In general the Palestine is a somewhat more thinly bedded and less massive sandstone than the older Chester sandstones, although most of the lower formations do become as thinly bedded locally as the Palestine, and the Palestine itself is very massive in the neighborhood of Glendale in Pope County. The texture and color of the Palestine is similar to the other Chester sandstones, being

fine grained and yellowish brown, but on the whole the color is decidedly paler than that of the Tar Springs especially, and to a less degree than that of the Waltersburg, Hardinsburg, and Cypress sandstones. Like the other sandstones in the series, the formation exhibits a considerable amount of variation in its characters, and in isolated outcrops, out of relation to any limestone formation of the series it would be difficult and probably impossible to identify the formation with any certainty.

Thickness. The Palestine is one of the thinner sandstones of the Chester series, although it nowhere in southern Illinois, so far as observations have been carried, is entirely wanting, as is the Waltersburg. The maximum thickness of the formation in the two counties is probably in the region east of Bay Creek for a distance of five miles or so. A very close estimate of the thickness of the formation in this region can be made in SE¼ of NE¼ of Sec. 36, T. 12 S., R. 4 E., about one mile northeast of Flatwoods, where both the lower and upper contacts of the formation can be quite closely determined, the thickness being very close to 80 feet. Elsewhere the formation is much thinner, it being only about 40 feet in NE¼ sec. 32, T. 12 S., R. 4 E., about two miles north of Wartrace in Johnson County. The most usual thickness of the formation is probably about 60 feet.

Stratigraphic Relations. The stratigraphic relations of the Palestine sandstone with the underlying Menard limestone has already been considered, and it seems probable that the sandstone lies unconformably upon the limestone. The relations of the sandstone with the overlying Clore formations are not at all clear, but it seems to be probable that the sedimentation was continuous from the Palestine into the overlying Clore. In one Randolph County section the gradual change from sandstone into sandy shales and the more argillaceous shale is clearly shown in at least one section, and the same condition seems to obtain in Pope and Johnson Counties, although no clearly exposed section from one formation into the other has anywhere been observed.

Paleontology. The fossils of the Palestine sandstone are limited to more or less imperfect plant remains, among which the trunks of Lepidodendron are most common. Trunks of this sort, three or four inches in diameter are more common in the Palestine than in any other of the Chester sandstones, and some examples six or eight feet in length have been observed. Fragments of similar trunks are met with in all of the sandstones of the series, and all seem to represent a common species.

Correlation. Like the underlying Menard formation, the Palestine can be traced continuously from the southeastern part of Illinois in Hardin County, to the Mississippi river section in Randolph County, with the exception of a short gap in southwestern Jackson county where the belt of outcrop is not exposed. This being the situation there are no questions concerning the correlation of the formation across Illinois at least.

Clore Limestone

Distribution. The outcropping belt of the Clore formation is continuous across Pope and Johnson Counties, except where it is interrupted by faulting, and can be traced westward into Union County. It is present again in Jackson and Randolph Counties, following an interruption of some miles across southwestern Jackson County, on both sides of the Big Muddy River. The belt is narrow, rarely exceeding one-fourth mile, and the formation itself is obscured in many places by reason of its own non-resistant character and because of the sandstones which overly it throughout most of its extent. The belt is subparallel with the underlying belt of Palestine sandstone, and is commonly present in the lower slope of a more or less well defined escarpment, although this escarpment is not so conspicuous a topographic feature as is that of the Golconda and Glen Dean limestones.

Lithologic character. As it is represented in Pope and Johnson Counties, the Clore formation includes a larger proportion of shale than any of the other calcareous formations of the Chester series, but it does include a number of very persistent limestone beds. The shales are thinly laminated and fissile, some beds are wholly argillaceous, others are more or less calcareous. The more calcareous shale beds commonly include numerous more or less discontinuous, thin layers of limestone, an inch or two in thickness, some of which are highly fossiliferous.

The most persistent limestone bed of the formation is at the top. It is commonly 2 or 3 (?) feet thick, in a number of layers 8 or 10 inches thick. These layers are rather dense and compact in texture, somewhat siliceous, and weather in an hour-glass shape on the vertical joint faces. The beds are separated by thin, shaly layers, and the lamination continues for a little distance into the more solid limestone layers themselves, the middle part of each layer being the most compact, likewise the most pure calcium carbonate, hence the weathering back by solution of the medium portion of the layers to give the hour-glass shape.

The color of the shales of the Clore formation vary somewhat, but are in general, grey, bluish or in places slightly greenish. No red shales have been seen. The limestones vary in color and texture. The thicker beds are dark, commonly being essentially black. Some of the beds are much lighter in color, one very persistent bed of nodular limestone in Johnson County being quite light gray, and very compact in texture. Some of the more fossiliferous beds are brownish, being decidedly yellow brown upon the weathered surfaces at least.

One of the best exposures showing the section of the Clore formation is in the cut of the C. & E. I. Railroad in SW¼ of SW¼ sec. 23, T. 12 S., R. 2 E., about halfway between West Vienna and Buncombe. At this point the following section is exposed.

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Thickness. Across Johnson County and in most of Pope, the thickness of the Clore formation is quite uniformly about 40 feet, but as the formation is traced eastward into Hardin County it seems to become reduced in thickness. In much of the belt of outcrop it is not practicable to determine the thickness with accuracy because of the covering of the sections with surficial material, but the possible interval for the formation is approximately 40 feet.

Stratigraphic relations. From a consideration of distances elsewhere it seems probable that the sedimentation was continuous from the underlying Palestine sandstone into the Clore formation, the transition taking place from the sandstones through arenaceous shales into more calcareous shales and limestones. There is no definite evidence of any stratigraphic break at the top of the Clore. Above the persistent limestone member near the summit of the formation, the shale beds change from a more calcareous to a somewhat arenaceous condition and then to thinly bedded sandstones which merge into the more massive beds. One of the best exposures of the transition from the Clore into the overlying Degonia sandstone in Johnson County may

be seen in the small ravine which crosses diagonally from southwest to northeast, the SW¼ of SE¼ sec. 30, T. 12 S., R. 4 E. The Clore is exposed nearly to its base in this ravine, but is cut off by the Wartrace fault which brings the upper part of the Palestine sandstone in contact with the Clore to the west.

Paleontology. The limestone bands in the Clore are more or less fossiliferous, and some of the more calcareous shales also carry a good many fossils. One horizon near the middle of the formation contains a larger number of fossils among which the bryozoans are especially numerous upon the westward surfaces of thin limestone slabs. Fenestellids, including Archimedes are abundant, but associated with them are great numbers of a small dendroid form with cylindrical branches, apparently a species of Batostomella, which differentiates these beds from any other bryozoan horizon in the Chester series, and this same faunal characteristic is present in the Clore as far as the formation can be traced in Randolph County.

The following fossil lists give some idea of the constitution of the Clore faunas throughout Pope and Johnson Counties.

* * * * *

Correlation. The continuity of the Clore formation across the southern counties of Illinois and in Jackson and Randolph Counties along the Mississippi river, eliminates all question of correlation of the Clore formation in Illinois. From the Menard limestone up, the section in Pope and Johnson Counties is the same as that in Union, Jackson and Randolph Counties in all its units.

Degonia Sandstone

Distribution. The Degonia sandstone is an important formation in the Chester series across the whole of Johnson County and much of Pope County, but it seems to become thinner and may even disappear entirely ~~entirely~~ in eastern Pope County. The formation, however, reappears in Hardin County and is well developed between the Clore and Kaskaskia limestones. The belt occupied by the outcrop of this formation is a mile or more in width throughout much of its extent across Johnson County and to the Reevesville fault in Pope County, but east of the Brownfield fault is much less conspicuous. The belt is subparallel with the belts of the older formations and is continuous throughout its extent except where it is interrupted by faults.

This formation is perhaps more nearly continuous across the gap in southwestern Jackson County where so many of the Chester formations are interrupted, than any other one. The sandstone is recognizable in the Mississippi river bluffs from the north to the gap formed by the Big Muddy River. The bluffs to the south of this gap have not yet been examined but it is quite likely that the formation can be traced continuously into Union County where it connects up with the belt of outcrop across Union, Johnson and Pope Counties.

Lithologic character. The Degonia resembles the other sandstones of the Chester series in most of its features. It is a fine textured sandstone, yellowish in color, and varying considerably in the character of bedding. In Pope and Johnson Counties its color is distinctly paler than some of the older sandstones, notably the Tar Springs, being similar in this respect to the Palestine sandstone, so similar indeed that it would be difficult to distinguish the two formations unless they were seen in relation to one of the adjoining limestones. The outcropping ledges of the sandstone are rather massive, but in sections which show the succession of beds there is commonly exhibited an alteration of the more massive beds with thinly bedded layers, more or less ripplemarked or hummocky along the bedding planes. One of the best

exhibitions of the formation showing the succession of massive and thinly bedded layers is in the ravine crossing the SE¼ sec. 22, T. 12 S., R. 4 E., about three-quarters of a mile south of Simpson.

(Section) * * * * *

In the more western extension of the Degonia sandstone, in Union and Jackson Counties, the formation becomes more massive and somewhat coarser in texture, and closely resembles some of the non-pebble bearing beds of the Pottsville. Indeed where the Pottsville rests upon the Degonia, as it does in places, it is practically impossible to draw a line of separation between the two formations. In this region the Degonia is a conspicuous cliff forming sandstone, and its massive character is shown in the vertical bluffs 50 feet or more in height which are present in many places in southeastern Jackson County.

Thickness. In the ravine section that has been mentioned near Simpson, the Degonia is at least 100 feet in thickness, and this thickness probably persists with but little variation across Johnson County. It is certainly as thick as this in Union County, and 100 feet is the normal thickness in Jackson County.

Eastward from Simpson, the formation gradually becomes thinner and there are places in eastern Pope County where it seems to be wanting altogether. This seems to be the situation in NW¼ sec. 10, T. 13 S., R. 6 E., about 4 miles northwest of Golconda, though the apparent absence in this place may be due to the faulting. Farther east, in Hardin County, the formation develops a considerable thickness, at least as much as 50 feet in places.

Stratigraphic relations. It has already been shown that the Clore limestone seems to pass into the westerly Degonia sandstone by a gradual transition through calcareous and arenaceous shales to thinly bedded sandstone, and that there is no evidence for considering the existence of any unconformity or break in sedimentation between the two formations.

The top of the Degonia and the contact with the overlying Kinkaid limestone has not been observed, so that the presence or absence of any relation of unconformity cannot be approved. Certain observations seem to indicate, however, that there is some recurrence of sandstone layers above the of the Degonia, which would suggest the continuity of sedimentation and a gradual change in the sedimentary conditions from the lower formation into the higher, and consequently the absence of any unconformity.

Paleontology. Like the other Chester sandstones the Degonia contains no distinctive fossils. A few fossil tree trunks belonging to the genus Lepidodendron are present which are similar to the examples which occur locally in all of the Chester sandstones.

Correlation. No questions in correlation across Illinois are involved in connection with the Degonia sandstone. The formations can be traced practically all the way from Hardin County to Jackson, having much the same character throughout its extent, and bordered throughout by limestone formations below and above, which also are similar in character, both lithologic and faunal, throughout their entire extent.

Kinkaid Limestone

Distribution. The highest formation in the Chester series of Illinois is the Kinkaid limestone. It is an important formation and occupies a rather broad belt across Pope and Johnson Counties, just outside of the Pottsville area lying to the north of it. In the downdropped block between the Reevesville and Brownfield faults there are considerable areas of Kinkaid apart from the general belt across the two counties. Thus areas within the faulted zone are considerably cut up, and some of the areas of outcrop extend as far south as the north border of the Bay bottoms, at Dixon Springs Station. East of the Brownfield fault the belt of Kinkaid limestone has a northeasterly direction for a point about $4\frac{1}{2}$ miles northwest of Golconda to near the northeastern corner of Pope County.

Lithologic character. In general the Kinkaid limestone resembles the Menard in its lithologic character, more closely than any other of the Chester limestones, but it deffers from that formation in several notable features. Like the Menard, the formation has been deepened in general in a succession of even beds which are commonly from eight inches to a foot in thickness. These layers exhibit in many places, the same sort of hummocky bedding as that seen in the Menard, and many of the beds are of the same sort of hard, compact, dense limestone, which breaks into a conchoidal or splintering fracture. The color of the limestone also resembles the Menard, being light or dark gray, and the surfaces of many of the ledges weathers much the same smoothness. The two formations are really so much alike in some parts at least, that the sandstones under which they were deposited must have been very similar.

In some respects, however, the Kinkaid differs notably from the Menard. The formation contains a very large amount of chert in many localities in Pope and Johnson Counties, this chert in places being in beds one or two feet thick and massive in character. These chert beds break up on weathering and the fragments up to a cubic foot in dimension are strewn on the hillsides, along stream beds, and along roads in numerous localities. Much of this chert is light colored, some with a greenish tint,

in contrast with the dark cherts of the Vienna limestone. Another characteristic of the Kinkaid limestone is the presence in Pope and Johnson counties of one or more conspicuous beds of red shales near the bottom of the formation, and the red shales are commonly accompanied by other beds of olive green shales.

Although the limestone beds of the formation do resemble the Menard in many respects it is true that there are a greater number of more or less crystalline beds associated with the more compact layers than in the Menard.

In addition to the limestone and shale beds of the Kinkaid there has been observed in places, apparently in the lower portion of the formation, some thin layers of sandstone. These sandstone beds are in all cases rather thin bedded and more or less impure.

Thickness. Where the Kinkaid limestone is best developed there is a thickness of over 100 feet. This is the condition extending into the northern part of Sec. 9, T. 12 S., R. 2 E., two miles northwest of Buncombe. At this locality there is apparently about 140 feet of the limestone. In the belt extending eastward from this locality the thickness apparently varies from this maximum amount to a minimum of 60 to 75 feet, the variation doubtless due to the differentiation sub-Pottsville erosion.

Further observations need to be made on the thickness of the formation across Pope County where it has not been separated from the Degonia and Clore in the mapping that has been done.

Stratigraphic relations. The stratigraphic relations of the Kinkaid limestone with the underlying Degonia sandstone has already been discussed. At the top of the formation an unconformity is everywhere present, with the Pottsville sandstones overlying it. The pre-Pottsville unconformity is marked by the uncovery of the Pottsville sandstone which contains numerous smoothly rounded white quartz pebbles in many localities, and in places there is a distinct basal conglomeration in the bottom of the Pottsville. At one locality in SE$\frac{1}{4}$ of NW$\frac{1}{4}$, sec. 18, T. 12 S., R. 5 E., three miles northeast

of Simpson, the basal conglomeration is well exhibited with numerous limestone pebbles which must have been derived from some of the underlying limestones, and an occasional red granitic pebble which must have been brought a long distance.

Paleontology. The limestones of the Kinkaid formation are more or less fossiliferous, but the fossils are commonly rather firmly imbedded in the matrix and are consequently rather difficult to collect in good condition. An insufficient number of collections have been studied as yet to allow of a complete discussion of the fauna of the formation. The general composition of the fauna is similar to that of other limestones of the Chester series, with brachiopods, molluscs and bryozoans. The bryozoan layers, however, are not nearly so conspicuous in this formation as in most of the other Chester limestones, and really constitute a rather subordinate element in the fauna. The brachiopod genera are those which occur generally in the Chester formations. The Spirifers are of the Sincrebescus type and are commonly large forms similar to those in the Clore and Menard. The Composita on the other hand are more commonly of the smaller types which were conspicuous in the middle and lower Chester limestones. A common member of the fauna in a number of localities rather widely separated is Martinea, the genus being more commonly met with in this highest Chester limestone than at any other horizon in the series except perhaps in the lower portion of the Okaw limestone in Randolph County. Among the pelecypods of the facies should be mentioned Sulcatopinna missouriensis which is such a common form in the Menard ls. and Allorisma clarata which is associated with the Sulcatopinna in the Menards.

Correlation. The continuity of the Chester formations from the Palestine sandstone to the top of the series, across southern Illinois and into the Mississippi river counties, Jackson and Monroe, makes the question of the correlation of this formation across the state, very simple. Like the other formations the Kinkaid can be practically traced from Hardin County on the southeast to Randolph County at the northwest, with the exception of a gap across the southwestern part of Jackson County.