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THE STE. GENEVIEVE FORMATION AND ITS STRATIGRAPHIC RELATIONS IN SOUTHEASTERN IOWA.

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In his report on the geology of Lee county[1] Keyes described a fine-grained, compact limestone at the top of the St. Louis formation, resembling lithographic stone in texture. Gordon[2] reported a similar limestone characterized by *Spirifer littoni* (=*Spirifer pellaensis* Weller) and *Pugnax ottumwa* at the same horizon in Van Buren county. Bain[3] subsequently recognized this member in Keokuk county and named it the Pella because of its typical development at the town of this name in the neighboring county of Marion. This name has been adopted by Savage in his geology of Henry county[4] and by Miller in the Marion county report.[5] Until 1900, when Nickles and Bassler[6] referred the Pella to the Ste. Genevieve upon the basis of its bryozoan fauna, the St. Louis age of the formation was accepted without question. Weller[7] subsequently pointed out the Ste. Genevieve affinities of the Pella fauna in 1909, and recent field studies have now likewise demonstrated that the Pella is formationally distinct from the underlying St. Louis, it being separated from that formation by a disconformity and by a characteristic basal sandstone in every Iowa locality which has come under observation.

Areal Distribution.—In general, the exposures of the Pella beds in Iowa are confined mainly to the southeastern part of the state. In the belt of Mississippian rocks, which extends northwestward from this region, the higher formations of the system are concealed by the Coal Measures, except for locally exposed areas in Story, Webster and Humboldt counties, where the overlying beds have been removed by erosion. Little is known as to the extent of the Pella in this direction, but the finding of a good Pella fauna by Wilder[8] in certain marls overlying the St. Louis limestone in Webster county indicates that the Pella seas extended at least as far northward as Fort Dodge.

[1]Ia. Geol. Survey, Vol. III, 1893, p. 349.
[2]Ia. Geol. Survey, Vol. IV, 1894, p. 217.
[3]Ia. Geol. Survey, Vol. IV, 1894, p. 282.
[4]Ia. Geol. Survey, Vol. XII, 1901, p. 265.
[5]Ia. Geol. Survey, Vol. XI, 1900, p. 143.
[6]U. S. Geol. Survey Bull. 173, pp. 166 and 188.
[7]Jour. Geol., Vol. XVII, p. 278.
[8]Ia. Geol. Survey, Vol. XII, 1901, p. 78.

In southeastern Iowa, Coal Measures strata also frequently cap the Mississippian. But this higher formation has been long since stripped off in many areas. In this region the Pella is preserved mainly in the form of local outliers due to both pre-Pennsylvanian and post-Pennsylvanian erosion. Small scattered exposures occur in Lee, Des Moines, Henry, Washington and Keokuk counties, and outcrops appear at intervals along the Des Moines river and its tributaries in Van Buren, Wapello, Mahaska and Marion counties. It is best known to the writers as developed in Van Buren county.

Lithologic Characters and Stratigraphic Relations.—Lithologically the Pella is very variable, and it is impossible to give a general description of its character which will hold in all cases. For this reason, it seems desirable to present a number of detailed sections, in order that its variability may be better understood. These sections will also show the stratigraphic relations and thicknesses of the formation at those points where it has been most carefully studied.

SECTION I.

Section along bed and banks of a small creek emptying into the Des Moines river in the lower part of the town of Croton, Lee county, Iowa.

	FEET.	INCHES.
PENNSYLVANIAN:		
15. Sandstone, yellowish, soft. (disconformity)		
PELLA:		
14. Limestone, compact, light gray above but dark gray below, containing a bed of calcareous shale 2½ feet thick in middle portion, about	9	
13. Sandstone, yellowish, fine-grained, sometimes soft and shaly in lower portion; contact with bed below uneven; bearing large fucoid-like markings on surface of layers (disconformity)	4	3
UPPER ST. LOUIS:		
12. Limestone, gray, granular to compact, locally slightly oölitic in part; middle portion cross-bedded, a layer in lower portion bearing conspicious wave marks on its upper surface	10-13	
11. Limestone, bluish, dolomitic, thinly bedded, somewhat shaly, slightly fossiliferous, resting on the undulating surface of the bed beneath	2	

		FEET.	INCHES.
10.	Limestone, compact, gray, consisting of moundlike masses of a conglomeratic limestone flanked by more evenly bedded, less disturbed layers..... (disconformity)	13	
LOWER ST. LOUIS:			
9.	Limestone, massive, compact, dolomitic, gray when fresh but weathering yellowish. The *Lithostrotion canadensis* zone	0-2	
8.	Limestone, buff, dolomitic, massive, flaking off obliquely, fossiliferous in lower portion	4½-5	
7.	Limestone, gray when fresh but weathering buff, dolomitic, locally grading wholly or in part into dark gray, non-dolomitic, conglomeratic limestone	7	6
6.	Limestone, bluish when fresh but weathering buff, fucoidal	3	6
5.	Limestone, brownish, dolomitic, tough, with discontinuous seams of unaltered gray limestone in upper portion.		
4.	Limestone, drab, compact, brittle, with numerous rounded chert concretions, arching up over moundlike masses of bed beneath, about	2	
3.	Limestone, conglomeratic, consisting of mingled blocks of gray compact limestone; gray subcrystalline limestone; brownish dolomitic limestone, and soft bluish limestone either in a shaly or a calcareous matrix	12-13	
2.	Limestone, gray, compact, dense, dolomitic in basal portion, with thin wavy and concretionary stratification..... (disconformity)	1	6
WARSAW:			
1.	Shale, bluish, argillaceous (exposed).....	5	10

The Pella beds are again well exposed at an abandoned quarry on the south bank of Indian creek, 3½ miles west of Farmington (N. W. ¼ N. E. ¼ Sec. 5, T. 67 N., R. 8 W.). The succession in this quarry and in the creek below is as follows:

SECTION II.

		FEET.	INCHES.
12.	Drift, yellowish, sandy	0-8	
PELLA:			
11.	Limestone, light gray, dense, lithographic-like, breaking with conchoidal fracture, becoming coarser-grained and slightly crinoidal in the upper portion; in rather heavy layers separated by thin partings of shaly limestones, locally seamed with calcite veinlets following fractures; some layers exhibiting stylolytic structure....	8	6

		FEET.	INCHES.
10.	Shale, bluish, argillaceous, with calcareous seams bearing many pelecypods near top	3	5
9.	Limestone, gray, subcrystalline, with thin discontinuous seams of fine-grained sandstone in thin, undulating layers, bearing a few small pelecypods		9
8.	Sandstone, fine-grained, rather soft, light gray when fresh but weathering yellowish; in some places with angular chert fragments in basal portion (disconformity)	0-2	
UPPER ST. LOUIS:			
7.	Limestone, gray, subcrystalline, in rather heavy layers; upper surface irregular	2½-4½	
6.	Limestone, dark gray, subcrystalline, compact; often filled with small sinuous, tubular, branching fucoids; bearing large rounded calcareous algae		2-6
5.	Shale, fissile, bluish when fresh but weathering drab, becoming more calcareous in upper portion	1	5
4.	Limestone, gray, compact, grading up into the bed above	1	10
3.	Limestone, gray, compact, exhibiting fine wavy stratification		6
2.	Limestone, gray, compact, thin-bedded	1	8
1.	Limestone, gray, granular to compact, locally cross-bedded in part, bearing large rounded calcareous algæ in upper portion	12	6

A few rods below the point of the foregoing section, an exposure in the north bank of the creek along the Chicago, Burlington and Kansas City railway shows twenty-one feet of Pella beds overlain disconformably by five feet of Pennsylvanian sandstone.

Other important exposures of the Pella beds appear in the bluffs of the Des Moines river and along its tributary, Reed creek, northwest of Farmington.

In a section exposed in the northeast bluff of the Des Moines river and in the railway cut of the Chicago, Rock Island and Pacific Railway two miles north of Farmington (S. W. ¼ Sec. 23, T. 68 N., R. 8 W.) the Pella is seen to rest directly upon the Lower St. Louis.

SECTION III.

		FEET.	INCHES.
PELLA:			
4.	Limestone, compact, gray, brecciated, capping brow of bluff	3	4
3.	Concealed. Slope strewn with loose blocks of compact gray limestone	31	

		FEET.	INCHES.
2.	Sandstone, fine-grained, light gray above but yellowish below, soft, bearing rounded and subangular blocks of gray dolomitic limestone ..... (disconformity)	21	6
LOWER ST. LOUIS:			
1.	Limestone, brecciated, gray to buff, imperfectly dolomitized, exposed to level of track	16	

In the exposures on Reed creek the Pella beds are exceptionally well developed. A remarkable section exhibiting both the Pella and the whole of the St. Louis as developed in Iowa, appears in the south bluff of the creek about three-fourths of a mile above its mouth (N. E. ¼, N. E. ¼, Sec. 14, T. 68 N., R. VIII W.). The succession, as measured near the middle of the bluff, is as follows:

SECTION IV.

		FEET.	INCHES.
11.	Drift.		
PELLA:			
10.	Limestone, light gray, compact to subcrystalline, some layers lithographic-like and breaking with conchoidal fracture; layers 1 inch to 1½ feet thick, separated by shaly partings which are locally highly fossiliferous; in places exhibiting stylolytic structure; becoming shaly in lower portion and grading downwards into the bed below; locally brecciated in part....	21	6
9.	Shale, bluish, argillaceous to calcareous, of variable thickness due to mashing.....	3-6	
8.	Limestone, light gray, compact, in thin, irregular layers with shaly partings.....		9
7.	Sandstone, bluish, fine-grained, rather soft, bearing rounded and subangular pebbles of compact gray limestone.....	6	
6.	Limestone, gray, compact in middle but subcrystalline above and below.....		4
5.	Sandstone, bluish, fine-grained, calcareous, massive, bearing rolled chert fragments (disconformity)	3	
UPPER ST. LOUIS:			
4.	Limestone, buff, dolomitic, arenaceous.....	6	
3.	Limestone, buff, dolomitic, massive.....	2	9
2.	Limestone, buff, dolomitic with small irregular remnants and blocks of compact gray limestone, slightly brecciated..... (disconformity)	9	
LOWER ST. LOUIS:			
1.	Limestone, buff, dolomitic, badly mashed and brecciated, shaly in lower portion...	28	

Other sections measured nearby in the same bluff showed considerable variation from that given above, owing to differential erosion of the St. Louis prior to the deposition of the Pella and to the variable character of the basal beds of the Pella itself. The section presented, however, may be regarded as typical.

In another bluff on the opposite side of Reed creek, about 300 yards above the location of the preceding section, the Pella beds are seen to rest upon somewhat lower beds of the Upper St. Louis. At this point, bed No. 10 of the foregoing section is represented by 18 feet of limestone; bed No. 9 by 3½ feet of shale; and beds 5, 6, 7 and 8 collectively by a continuous bed of sandstone varying from 24 to 34 feet in thickness. The underlying St. Louis is badly mashed for the most part, and towards the top the matrix of the brecciated limestone is abundantly filled with sand grains derived from the overlying formation. The basal sandstone of the Pella attains a similar development in the vicinity of Keosauqua, whence the name Keosauqua sandstone as applied by Gordon.[9] It there in many places includes discontinuous, lenticular masses of compact, sparsely fossiliferous limestone.

Fauna.—As regards the fauna of the Pella beds, at least two distinct faunal zones are distinguishable. These are represented in the thin shale bed which usually follows the unfossiliferous basal sandstone and in the overlying limestone member which normally caps the formation in southeastern Iowa. The shale member is characterized predominantly by a pelecypod fauna, but the brachiopod, *Pugnoides ottumwa,* and a small ostrocod, *Leperditia* sp., are also common. In the Indian creek section (Section II, bed 10), this bed yields the following forms:

Pugnoides ottumwa (White)
Sphenotus (several undescribed species)
Nucula illinoisensis Worthen?
Leda curta M and W.?
Myalina sp. undet.
Schizodus (several undescribed species)
Aviculopecten sp.
Modiola sp.
Allorisma (species undescribed)
Solenospira sp.
Leperditia sp. undet.

A collection from the same bed on Reed creek (Section IV, bed 9) yielded the following species:

Pugnoides ottumwa (White)
Solenomya? iowensis Worthen?
Sphenotus (several undescribed species)
Glossites (species undescribed)
Edmondia (species undescribed)

[9]Ia. Geol. Survey, Vol. IV, 1894, p. 217.

Nucula? sp.
Leda curta M. and W.?
Pinna (species undetermined)
Myalina? sp.
Myalina (species undetermined)
Schizodus (several undescribed species)
Aviculopecten (species undetermined)
Allorisma (species undetermined)
Leperditia (species undetermined)

The limestone following the shale bears a fauna consisting almost entirely of brachiopods, the pelecypods so characteristic of the underlying shale being almost entirely wanting. The following list of species identified from a collection made from this bed as developed along Indian creek (Section II, bed 11) is representative:

Rhombopora (species undetermined)
Productus ovatus Hall
Pugnoides ottumwa (White)
Girtyella indianensis (Girty)
Spirifer pellaensis Weller
Composita trinuclea (Hall)?
Allorisma sp.
Bellerophon sp.
Phillipsia? sp.

Of the above forms *Spirifer pellaensis* ranks first in abundance, while *Pugnoides ottumwa* is a close second.

A comparison of these Iowa collections with those which have been made from the typical exposures of the Ste. Genevieve limestone in Ste. Genevieve county, Missouri, and from exposures in Monroe county, Illinois, demonstrates the identity of the faunas. A number of the undetermined pelecypods of the Iowa collection are clearly undescribed, and are identical with species which have been collected in the Missouri and Illinois localities. As in Iowa, so in Illinois and Missouri, *Pugnoides ottumwa* is the most persistent index fossil of the fauna, and on the basis of these faunal resemblances the correlation of the Pella beds of Iowa with the Ste. Genevieve limestones may be considered as being fully established.

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