

THE STRATIGRAPHY OF THE INDEPENDENCE SHALE OF IOWA.

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PART I.

ABSTRACT. Since its initial discovery and description by Calvin, the stratigraphic position of the Independence shale has been in dispute among authors generally. In this paper are summed up all available evidences seen in natural and artificial exposures and secured from deep and shallow well records. All concur in indicating that, normally, the Independence shale lies immediately below the Cedar Valley limestone and above the Wapsipinicon formation. As the Independence has a definitely lower Upper Devonian fauna, the relative age of the superjacent Devonian formations of Iowa is evident.

THE DEVONIAN SECTION OF IOWA.

THE Devonian beds of Iowa are mainly limestones with subordinate beds of shale and rare sandstone. As worked out at the present time, the columnar section of the formations and members recognized is as follows:

Formation	Members	Lithology
Sheffield	undivided	shale and sandstone
Lime Creek	{Owen Cerro Gordo Juniper Hill	limestone shale shale
Shellrock	{Nora Rock Grove Mason City	limestone limestone limestone
Cedar Valley	{Coralville Rapid Solon	limestone limestone limestone
Independence	undivided	shale
Wapsipinicon	{Davenport Spring Grove Kenwood ¹ Otis Coggon	limestone, lithographic limestone, dolomitic shale and limestone limestone, sublithographic limestone, dolomitic

There are considerable differences of opinion among authors regarding the age of some of the formations. The Sheffield is

¹ The name Kenwood, as used by Norton, 1894, antedates the usage of the term by Butts for a Mississippian formation in 1915.

placed in the basal Mississippian by some and in the Upper Devonian by others.²

The Hackberry formation of Webster and authors includes the Cerro Gordo and Owen members of the Lime Creek but not the Juniper Hill shale. Hackberry and Lime Creek then are not equivalents. The column of Iowa Devonian formations ascribed by Cooper³ to the present writer has the Hackberry formation intercalated between Shellrock and Sheffield. Hackberry as an Iowa formational term is not recognized by the Iowa Geological Survey and has never been used as equivalent to the Lime Creek by the present writer. The Lime Creek and Shellrock are generally recognized as Upper Devonian age.

The Cedar Valley is variously placed in the Middle and in the Upper Devonian. Since its age will be determined by the position of the Independence shale and, as its fauna is the subject of another paper, it need not be further considered here.

The Independence shale has a fauna which everyone recognizes is Upper Devonian. Its stratigraphic position, in dispute, is the subject of the present paper and is discussed fully in the following pages.

The Wapsipinicon because of its scant fauna cannot be definitely assigned to any age at present.

The State Quarry limestone is distinctly younger than the Cedar Valley but cannot at this time be unquestionably correlated with any known formation, nor can its position relative to the Lime Creek or the Shellrock be determined with the evidence now at hand.

HISTORY OF PREVIOUS INVESTIGATIONS.

The first mention of the Independence shale as far as known occurs in the *Civilian*, an Independence, Iowa, newspaper for March 12, 1857. A public well sunk a short way east of the river bank passed through twenty feet of limestone (Cedar Valley) and entered dark shale which contained carbonaceous matter resembling "cannel coal."

Sometime before 1877 shale and coal were discovered beneath the basal beds of a quarry in Cedar Valley limestone one mile east of Independence. A shaft in search of supposed coal deposits was sunk not far away. A depression indicating the

² Moore, R. C.: 1935, *Kans. Geol. Society, Ninth Annual Field Conf.*, p. 245, fig. 202.

Laudon, L. R.: 1935, *idem.*, p. 246.

³ Cooper, G. A.: 1942, *Bull. Geol. Soc. Amer.*, vol. 53, p. 1737.

location of this pit is still visible with fossiliferous shale and carbonaceous clay about it.

This shale discovery was brought to the attention of Dr. Samuel Calvin of the State University of Iowa who studied the area and collected fossils in the material thrown out of the pit. His results were given in a paper read before the Iowa Academy of Science on June 23, 1876, and later published as a part of the Bulletin IV of the United States Geological and Geographical Survey of the Territories. In this article the shale was described and named and descriptions given of several new species of fossils.

In 1880 W. H. Norton published in the Cedar Rapids Republican, a newspaper for February 21, the section of the pit dug at Independence in search for coal. This section is given later in this paper.

In 1891 Calvin described in a preliminary report on the geology of Buchanan County, Iowa, the section at Independence and stated that the Independence shale occurred below the Cedar Valley limestone but above brecciated limestone. The following year he corrected his section, noting that the brecciated limestone was the same as the strata immediately above the shale. He adds "a few points have been found where the shales, by a little digging, may be seen beneath the breccia."⁴

Norton⁵ placed the Independence shale below a brecciated unfossiliferous lithographic limestone to which he gave the name "Lower Davenport."

Norton noted the occurrence of fossiliferous shale in a railroad cut at Linn Junction, Iowa. This outcrop was rediscovered thirty years later by the present writer in the cut now long abandoned by the railroad. Norton also noted the recovery of a typical Independence fossil from blue shale 100 feet below the surface in a well drilled at Walker, Iowa. Norton states that in a well at Lafayette, Iowa, black shale and coal was found below four feet of soil and 80 feet of limestone (Cedar Valley). However, Norton⁶ considered the shale to be below the Fayette breccia and correlated it with the unfossiliferous Kenwood shaly limestone and shale.

⁴ Calvin, Samuel: 1891, Additional notes on the Devonian rocks of Buchanan Co., Iowa: Amer. Geol., vol. 8, p. 142.

—————: 1892, idem, vol. 9, p. 345.

⁵ Norton, W. H.: 1894, Notes on the Lower Strata of the Devonian series of Iowa: Iowa Acad. Sci. Proc., vol. 1, pt. 4, pp. 22-24.

⁶ Norton, W. H.: 1895, Geology of Linn County: Iowa Geol. Surv., vol. 4, p. 157.

Calvin,⁷ discussing the geology of Buchanan County, noted several occurrences of the shale, listed the fauna, and stated that the shales were the lowest recognized member of the Devonian in the county with the "Fayette breccia" and the Cedar Valley limestone above. Parenthetically it may be interpolated here that the term "Fayette breccia" as used by Calvin included basal Cedar Valley beds and that in all cases where "Fayette breccia" lies above Independence shale, it is basal Cedar Valley and not the lithographic Davenport ("Lower Davenport of Norton").

In 1916-17, M. A. Stainbrook found several fossiliferous exposures of the Independence shale near Brandon, Iowa. These were later investigated and reported on by A. O. Thomas⁸ and W. H. Norton.⁹ They concluded that the fossiliferous Independence shale lies somewhere below the Cedar Valley limestone and that its occurrence adjacent to Cedar Valley beds was due to the deformation and upthrusting of the plastic shale.

T. E. Savage¹⁰ stated that he had visited the original pit and dump at Independence, Iowa, and suggested that the shale was a pocket of Lime Creek shale in a crevice in Cedar Valley limestone.

G. S. Dille¹¹ reported the occurrence of a black bituminous pyritiferous shale near Palo, Iowa. He suggested that it might be correlated with the Independence shale. The present writer has since verified that this outcrop of shale is definitely Independence by finding several of its characteristic brachiopods therein.

S. W. Stookey¹² reported the roadside exposure of shale and limestone in the Amana communities in Iowa County. Fossils were obtained by him and submitted to the present writer who definitely identified them as Independence and not Lime Creek. Doctor Stookey, however, concluded that the shale beds at

⁷ Calvin, Samuel: 1898, *Geology of Buchanan County: Iowa Geol. Surv.*, vol. 8, p. 222.

⁸ Thomas, A. O.: 1920, *The Independence Shale near Brandon, Iowa: Iowa Acad. Sci. Proc.*, vol. 26, pp. 485-491.

⁹ Norton, W. H.: 1920, *Wapsipinicon Breccias of Iowa: Iowa Geol. Surv.*, vol. 27, p. 388.

¹⁰ Savage, T. E.: 1920, *The Devonian Formations of Illinois: Amer. Jour. Sci.*, 4th series, vol. 49, p. 180.

¹¹ Dille, G. S.: 1924, *Notes on the Occurrence of a Black Bituminous shale near Palo, Linn County, Iowa: Iowa Acad. Sci., Proc.*, vol. 30, pp. 441-443.

¹² Stookey, S. W.: 1932, *New Data on the Upper Devonian of Iowa: Iowa Acad. Sci. Proc.*, vol. 39, pp. 183-191.

Amana were Lime Creek and again correlated the Independence shale with that terrane.

At this same time W. H. Norton sent the present writer some fossils found in drilling samples from a shale below forty feet of limestone at Shellsburg, Iowa. These fossils were recognized as typical Independence forms. Norton¹³ published the log of this well in which the Independence shale is placed immediately below the Upper Davenport (basal Cedar Valley of Stainbrook).

S. W. Stookey¹⁴ having learned of Norton's discovery of fossils in the Shellsburg well, reiterated the interpretation that the shale was the remnant of strata occurring in erosion channels, solution cavities and joints in the Cedar Valley limestone and therefore younger.

M. A. Stainbrook¹⁵ summed up the current knowledge of the Iowa Devonian. He summarized the facts gained about the Independence shale after twenty years of study, discovery of some twenty new exposures, collection of hundreds of fossils from the shale and study of numerous well logs and samples. He separated the Independence shale from the Wapsipinicon as distinct from the Kenwood shale and placed it as indicated from all available evidence where Calvin had years before,—namely, below the Cedar Valley limestone and above the Davenport lithographic limestone.

E. H. Scobey¹⁶ following a lithologic study of the Wapsipinicon placed the Independence shale above the Cedar Valley although it is apparent that he saw but few of the exposures of the shale. He stated that there was not room for the shale between the Cedar Valley and the Davenport although the formations are unconformable and elsewhere have sandstone between. Later¹⁷ he stated his belief that the Independence shale is Lime Creek.

¹³ Norton, W. H.: 1935, Deep Wells drilled in Iowa: Iowa Geol. Surv., vol. 36, p. 350.

¹⁴ Stookey, S. W.: 1933, Status of Devonian Beds at Middle Amana: Iowa Acad. Sci. Proc., vol. 40, p. 133.

¹⁵ Stainbrook, M. A.: 1935, Stratigraphy of the Devonian of the Upper Mississippi Valley: Kansas Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 252.

¹⁶ Scobey, E. H.: 1938, Sedimentary studies of the Wapsipinicon Formation of Iowa: unpublished thesis, State University of Iowa.

¹⁷ Scobey, E. H.: 1940, Sedimentary Studies of the Wapsipinicon Formation of Iowa: Jour. Sed. Petrol., vol. 10, no. 1, p. 41.

A. K. Miller¹⁸ placed the Independence shale in the basal Upper Devonian.

S. W. Stookey¹⁹ again stated that the Independence shale is post-Cedar Valley and residual on it. To M. A. Stainbrook is mistakenly attributed this statement,—“It now seems to me almost certain that the Independence shale and its fauna have been let down into the Cedar Valley limestone and to be far out of normal stratigraphic position.” The present writer never made this statement and does not believe that it is in accord with the facts.

Stainbrook²⁰ stated that the Independence shale was Upper Devonian in age, distinct from the Lime Creek and present below the Cedar Valley limestone and above the Davenport beds.

Cooper²¹ discusses the Independence shale, first giving the position of the present writer and secondly that of Warthin and himself, namely, that the shale is not in normal position. In addition he states that the Independence fills sinks and caverns, has a spotty occurrence and has a fauna of Nunda or High Point age. In his appended chart, Cooper places the Independence below Cedar Valley in the Middle Devonian and indicates that the fauna is Upper Devonian between the Juniper Hill and Cerro Gordo members of the Lime Creek stage.

Schuchert²² in his columnar section places the Independence as a member of the Lime Creek beds between the Juniper Hill and the Cerro Gordo.

STRATIGRAPHIC POSITION OF THE INDEPENDENCE SHALE.

It is evident from the summary given above that there are several contrasting opinions regarding the position of the Independence shale in the Iowa Devonian column. By Norton the shale is regarded as a member of the Wapsipinicon formation occurring between the Otis limestone below and the litho-

¹⁸ Miller, A. K.: 1938, Devonian Ammonoids of America: Geol. Soc. Amer., Spec. Paper no. 14, p. 6.

¹⁹ Stookey, S. W.: 1939, Significance of Carboniferous and Late Devonian Material within the Iowa Devonian: Iowa Acad. Sci. Proc., vol. 41, pp. 227-231.

²⁰ Stainbrook, M. A.: 1940, Independence Shale in Iowa (abstract): Bull. Geol. Soc. Amer., vol. 51, p. 1978.

²¹ Cooper, G. A.: 1942, Correlation of the Devonian Sedimentary Formations of North America: Bull. Geol. Soc. Amer., vol. 53, p. 1766.

²² Schuchert, Charles: 1943, Stratigraphy of the Eastern and Central United States, p. 700.

graphic brecciated Davenport limestone above. This correlation of the Independence with the Kenwood which does occur in company with the Spring Grove in this situation is considered by the present writer to be disproved by the²³ complete stratigraphic, faunal and lithologic differences between the two terranes. Scobey²⁴ also notes that the Kenwood is only 25 per cent insoluble while the Independence is a true shale and insoluble for the greater part. No fossil of the Independence and no Independence has been found lying on Otis. Unless evidence is discovered to the contrary, the Independence may be considered as entirely distinct from the Kenwood member of the Wapsipinicon.

In the second place the Independence shale by some geologists (Savage, Stookey, Cooper²⁵) is considered to be out of normal position and to occur at or near the base of the Cedar Valley as portions of some younger formation filling caverns, crevices and erosion channels in the limestone. This post-Cedar Valley formation is said by several (Stookey, Scobey²⁶) to be the Lime Creek shale because of the superficial resemblance of its fauna to that of the Independence. It is shown in a current paper by the present writer that the Independence and the Lime Creek faunas are quite distinct and not of the same age. The thesis that the Independence shale is simply Lime Creek shale out of place is not a tenable one.

Granting that this conclusion is true, is there any other formation later than the Cedar Valley which could have been the possible source for the shale supposedly out of place at the base of the Cedar Valley? Cooper and Schuchert²⁷ suggest that there was such a formation and that it was intercalated between the Cerro Gordo and Juniper Hill members of the Lime Creek. Apparently they tacitly admit that the Lime Creek (Cerro Gordo member) could not be the source of the shale which Calvin designated as Independence. It is sufficient to

²³ Stainbrook, M. A.: 1935, op. cit., p. 252.

²⁴ Scobey, E. H.: 1940, op. cit., p. 41.

²⁵ Savage, T. E.: 1920, op. cit. pp. 179-180.

Stookey, S. W.: 1932, op. cit., 1932, p. 191.

Cooper, G. A.: 1942, op. cit., p. 1766.

²⁶ Stookey, S. W.: 1932, idem, p. 191.

Scobey, E. H.: 1940, idem, p. 41.

²⁷ Cooper, G. A.: 1942, idem, p. 1737.

Schuchert, Charles: 1943, op. cit., p. 705.

state here that there is no field evidence of this hypothetical formation in that stratigraphic situation. The Cerro Gordo beds overlie the Juniper Hill beds conformably and grade into them with no perceptible break.

Lastly the Independence shale is considered by others (Calvin and Stainbrook) to occur in normal stratigraphic position below the Cedar Valley limestone and above the Davenport, the uppermost lithographic member of the Wapsipinicon. The present writer after a study of the shale in all of the known outcrops believes that this conclusion is the only one in accord with the facts thus disclosed. Evidences in support of this contention are developed along three main lines: that afforded by undisturbed exposures of the formation, that given by a study of deep and shallow well records and samples and that presented by faulted exposures of the shale.

NATURAL EXPOSURES.

The most important evidence for the determination of the position of the Independence shale is yielded by natural exposures where the strata are in normal stratigraphic position and but little disturbed. These exposures are few in number as would be expected as they are all west of the outcrop belt where exposures would normally occur. They are found only in the deep valleys of the major streams.

Near Independence, Iowa, along the right bank of the Wapsipinicon river south of town and one mile distant from the original discovery pit, Calvin²⁸ noted the presence of shale below the basal beds of the Cedar Valley limestone. Years later the present writer saw this shale as Calvin described it and secured typical Independence fossils from it. At the present time the outcrops are usually obscured either by vegetation and river deposits or covered by water, but are unquestionably below the basal Cedar Valley beds.

About a mile and a half northwest of Quasqueton in Buchanan county is an elongate hill some two miles long and adjacent to the Wapsipinicon river. Scattered outcroppings of limestone show that it is composed almost wholly of Cedar Valley with the beds dipping southward. Along both sides of the hill typical fossiliferous Independence shale occurs at sev-

²⁸ Calvin, S.: *Geology of Buchanan County: Iowa Geol. Surv. vol. 8, p. 223.*

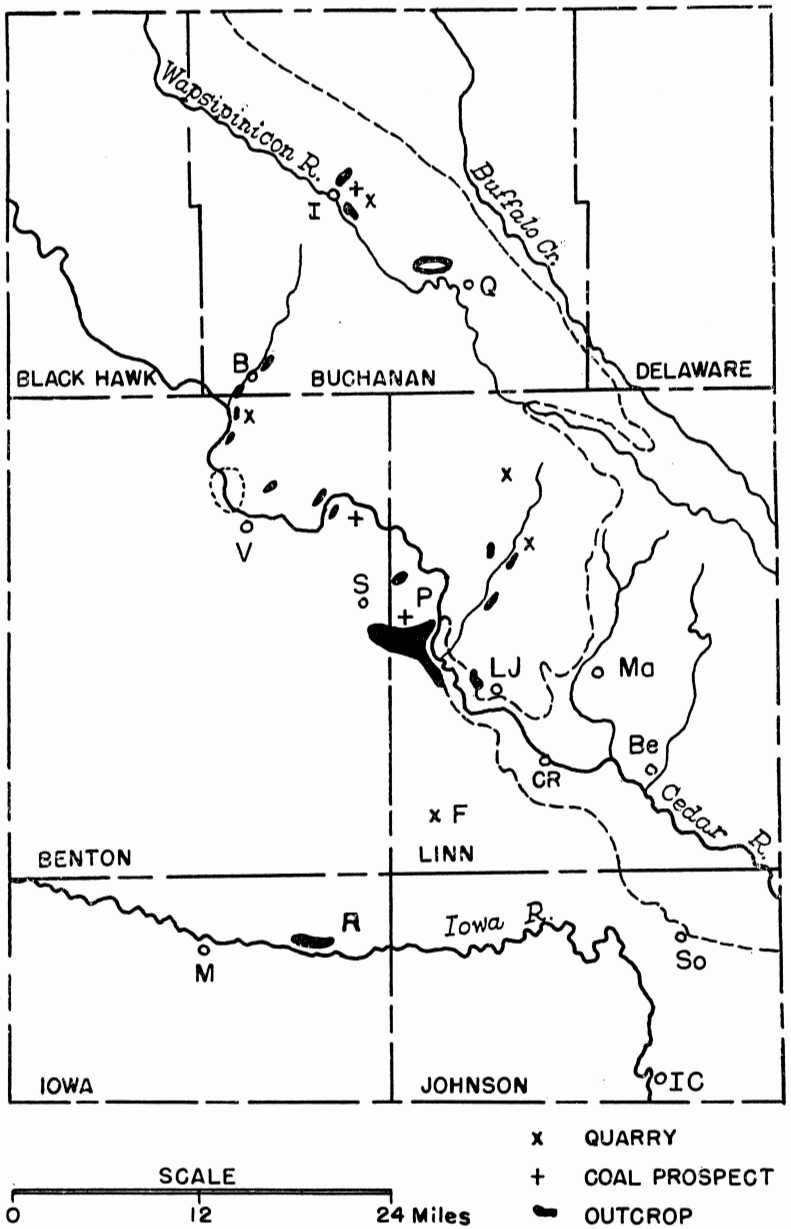


Fig. 1. Map of Benton, Buchanan, Linn and portions of adjacent counties, Iowa, showing local occurrences of the Independence shale. Outcrop areas are exaggerated. Key: A, Amana; B, Brandon; Be, Bertram; C.R., Cedar Rapids; F, Fairfax; I, Independence; I.C., Iowa City; L.J., Linn Junction; M, Marengo; Ma, Marion; P, Palo; Q, Quasqueton; S, Shellsburg; So, Solon; V, Vinton. The broken line is the approximate eastern border of the Cedar Valley limestone. The area at Amana is that of the Amana beds which are younger than Cedar Valley.

eral places beneath the basal layers of the Cedar Valley. The most illuminating exposure is seen on the west side of the north end of the hill where a freshet has recently (1940) uncovered the strata in a ravine in the bluff and has exposed the following section (see Fig. 2):

4. Pleistocene deposits.
3. 20 ft. limestone with numerous fossils: Cedar Valley.
2. 6 ft. blue-gray shale with fossils: Independence.
1. 2 ft. ledge of lithographic non-fossiliferous limestone: Davenport member of the Wapsipinicon.

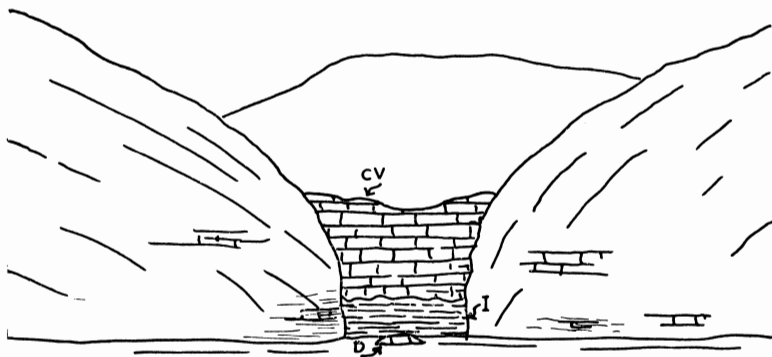


Fig. 2. Section revealed in ravine three miles northwest of Quasqueton, Iowa, showing 15-20 feet of basal Cedar Valley limestone overlying 5-6 feet of fossiliferous Independence shale. I, Independence shale; C.V., Cedar Valley limestone; D, block of Davenport limestone.

In none of the exposures around the hill is there a suggestion that the shale is in other than natural sequence and a continuous outcrop of several miles is indicated. At the south end of the hill the dip of the strata is sufficient to cause the shale to pass from view below the Cedar Valley limestone.

Another outcrop showing the shale in normal position is on East Otter Creek in section 8 of Monroe township of Linn county, Iowa. Here fossiliferous shale overlies typical brecciated Davenport limestone and underlies the fossiliferous *Gyroceras* beds which form the basal zone of the Cedar Valley.

On Little Bear Creek near Palo in the same county is another instructive exposure which has been described by Dille.²⁹ The shale was explored for coal and later as a possible source of cement materials. The shale apparently "was encountered in numerous borings along the valley" and thus appears to be

²⁹ Dille, G. S.: 1924, op. cit., p. 441.

present over a considerable area up and down the stream. A shaft was sunk into a low terrace in the north side of the broad valley. This shaft penetrated sixteen feet of gray and dark carbonaceous shale with coal and nodules of pyrite. Typical Independence fossils occur in the debris thrown out of the pit. To the south an eighth of a mile distant the south wall of the valley rises precipitously some sixty feet. Scattered ledges of rock show that the major portion of the hill is underlain by Cedar Valley limestone. Along the foot of the hill for a distance of several hundred feet the basal beds of the Cedar Valley outcrop. Directly beneath these Cedar Valley strata is Independence shale with typical fossils. This shale is on the same level as the deposit explored in the terrace on the north side of the valley. The relations are shown in the accompanying

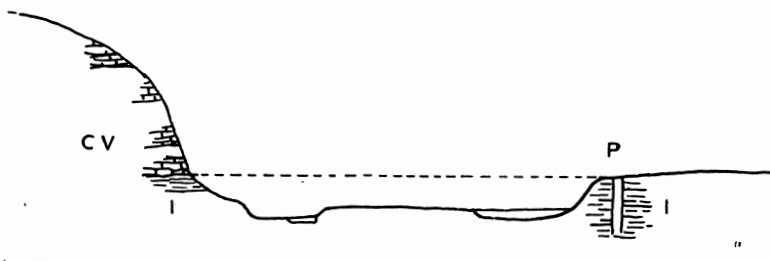


Fig. 3. Diagrammatic section on Little Bear Creek north of Palo, Iowa. The shale was penetrated for 16 feet by a coal prospect shaft and appears at the same level beneath Cedar Valley limestone about 40 rods to the southward. I, Independence shale. C.V., Cedar Valley limestone; P, coal prospect shaft.

diagram (Fig. 3). The extent of the shale in outcrop and as revealed by borings, its stratigraphic position and undisturbed nature precludes any hypothesis of the deposition of the shale in a cave below Cedar Valley limestone.

ARTIFICIAL EXPOSURES.

Further evidence of the stratigraphic position of the shale is that afforded by shafts and excavations. In that area of Iowa where Cedar Valley limestone forms the country rock, numerous reports of coal reached in wells and borings have been made. Several shafts³⁰ have been sunk in search of coal as in the instance at Independence where the shale was first brought

³⁰ Calvin, S.: 1878, U. S. Geol. and Geog. Surv., vol. 4, no. 3, p. 726. 1898, *op. cit.*, p. 251.

to light. The section in this shaft was published by Norton several years later (1880) and later³¹ given as follows:

Fossiliferous Hamilton limestone	20 feet.
Black fissile bituminous shale	12 feet.
Gray fossiliferous shale	4 feet.
Hard gray rock with pyrite	2 feet.

In this section the uppermost bed is certainly the Cedar Valley limestone. The two beds of shale are Independence and the lowermost bed seems to be the Davenport. A pit several feet deep is still visible showing the situation of this shaft about ten feet beyond the north face of a quarry in Cedar Valley limestone. Typical Independence fossils and samples of the carbonaceous shale are still present about the pit. A dug well sunk about 1857 in the city of Independence passed through 20 feet of limestone and encountered shale with coal below.

About six miles north of Shellsburg in Benton county, Iowa, at the old ferry landing on the south bank of Cedar river is Barr's Bluff. This is formed by the beds of the lower portion of the Cedar Valley formation. Years ago a shaft was sunk here and according to Misters Carver and La Tourene of Shellsburg, coal was actually taken from it at a depth of thirty feet.³² A pit still shows the site of the shaft and comparison with the neighboring exposure of Cedar Valley limestone to the immediate west demonstrates that a depth of thirty feet would reach the bottom of that formation.

At Lafayette, Linn county, Iowa, in 1877, a miner's shaft³³ was sunk which passed through four feet of soil, 81 feet of limerock (Cedar Valley) and uncovered a coal seam one inch thick. A half mile northeast of Lafayette in the east valley of the creek valley a quarry has been opened in the basalmost beds of the Cedar Valley. In a sump pit at the south end of the quarry, and below the limestone the present writer recovered blue shale with typical Independence fossils. In a quarry one and a half miles south of Alice in the same county, in a recent quarry, shale was disclosed beneath Cedar Valley and above Davenport lithographic limestone.

At Fairfax in Linn county, one block north of the C. and NW. station, a quarry was opened several years ago as a source

³¹ Norton, W. H.: 1920, op. cit., p. 309.

³² Savage, T. E.: 1905, Geology of Benton County: Iowa Geological Survey, vol. 15, p. 199.

³³ Norton, W. H.: 1920, Wapsipinicon Breccias of Iowa: Iowa Geol. Surv., vol. 27, p. 387.

of road material. The beds quarried are the basal beds of the Cedar Valley. At the south end a sump was made and blocks of blue-gray shale two feet thick and four feet long were brought up from below the Cedar Valley limestone. The shale was undisturbed and contained Independence fossils. The quarry has since been abandoned, partly because of the slight thickness of limestone available and because of the bogging effect of the shale below, when reached by the removal of the limestone.

On Little Bear creek near Palo, as disclosed by Dille,³⁴ a shaft $3\frac{1}{2}$ by $4\frac{1}{2}$ feet, was sunk into the Independence shale. The log in brief is:

3. $2\frac{1}{2}$ ft. gravelly yellow clay: Pleistocene.
2. 16 ft. black, and blue shale, alternating, with coal and pyrite seams: Independence shale.
1. Concretionary limestone and limestone: Wapsipinicon.

Since shale identified as Independence by its fossils is present beneath the Cedar Valley several hundred yards to the southward, the limestone beneath the shale could not be Cedar Valley.

The natural and artificial exposures of the Independence shale demonstrate that it occurs in natural sequence above the Davenport limestone and below the Cedar Valley consistently. The shale in several instances, as at Quasqueton and at Palo, is of such an extent as to preclude the interpretation of the shale as a cave deposit. Also on fresh exposure, the shale is seen to be normally bedded in horizontal layers in no way comparable to that to be expected in a cave or crevice filling washed down through 150 feet of limestone. That Cedar Valley and Shellrock fossils or blocks of limestones from these formations would escape being incorporated during the process of cave filling is nearly inconceivable. Yet in the undisturbed Independence in these exposures, the shale is uncontaminated by either Cedar Valley or Shellrock fossils and debris. It seems unescapable that the Independence shale was deposited prior to these two formations.

SHALLOW WELL RECORDS.

Numerous shallow well records attest to the presence of shale beneath the Cedar Valley limestone over a wide area. While

³⁴ Dille, G. S.: 1924, op. cit.

these records are not based on samples which can now be studied, they must be conceded some considerable degree of

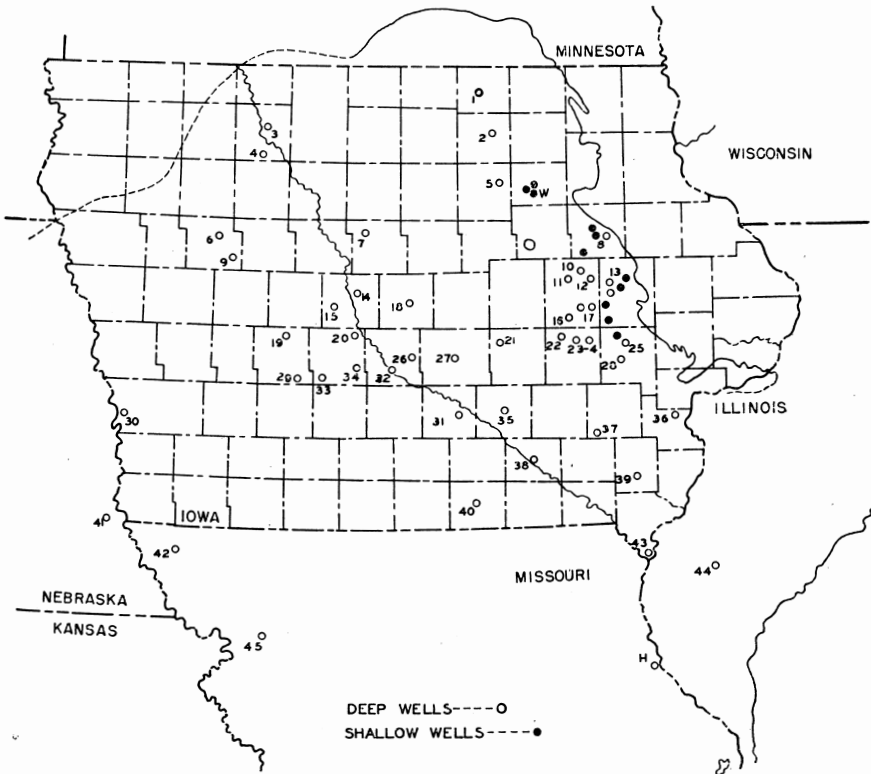


Fig. 4. Map of Iowa and portions of adjacent States, showing the occurrence of Independence shale in deep and shallow wells, Key: 1, Osage; 2, Charles City; 3, Emmetsburg; 4, Mallard; 5, Clarksville; 6, Sac City; 7, Webster City; 8, Quasqueton; 9, Auburn; 10, Vinton; 11, Garrison; 12, Shellsburg; 13, Center Point; 14, Boone; 15, Nevada; 16, Ogden, 17, Newhall and Atkins; 18, Watkins; 19, Bayard; 20, Woodward; 21, Grinnell; 22, Marengo; 23, South Amana; 24, Homestead; 25, North Liberty; 26, Mitchellville; 27, Newton; 28, Oakdale; 29, Stuart; 30, Dexter; 31, Waukee. 32, Des Moines; 33, Council Bluffs; 34, Flagler; 35, Oskaloosa; 36, Letts. 37, Brighton; 38, Ottumwa; 39, Mount Pleasant; 40, Centerville; 41, Nebraska City, Neb.; 42, Tarkio, Mo.; 43, Keokuk, Iowa; 44, Colmar-Plymouth area, Ill.; 45, St. Joseph, Mo.; H, outcrop of sandstone south of Hannibal, Mo.; W, Waverly, Iowa. The solid line is the approximate eastern limit of the Cedar Valley limestone; the broken line is its approximate subsurface boundary.

accuracy. An experienced well driller has little difficulty in distinguishing between shale and limestone as they are encountered by the drill in shallow borings. These records are extracted from the various reports on the geology of the county concerned. In all cases the interpretation of the formation and identification of the same is by the present writer.

In the northern part of the Cedar Valley outcrop is the Osage City well in Mitchell county, Iowa. The log is as follows:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-20	drift	Pleistocene Devonian
20-180	limestone	Cedar Valley
180-200	gumbo shale	Independence
200-660	limestone	Wapsipinicon and Silurian

In Bremer county several wells show shale below Cedar Valley as is evident in the logs of these wells.

William Coon well, one mile north of Waverly:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-75	drift	Pleistocene Devonian
75-120	limestone	Cedar Valley
120-122	shale	Independence
122-136	limestone	Wapsipinicon

E. Bennett well, three miles north of Waverly:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-10	yellow drift	Pleistocene
10-70	blue clay	Pleistocene Devonian
70-114	limestone	Cedar Valley
114-124	gray shale	Independence
124-138	limestone	Wapsipinicon

Wm. Colton well, three miles northwest of Waverly:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-20	drift	Pleistocene Devonian
20-50	limestone	Cedar Valley
50-65	black shale	Independence
65-92	limestone	Wapsipinicon

In Buchanan county where the Independence shale was first discovered and named, several well logs show shale below the Cedar Valley limestone.

In Jefferson township in the northeast one-fourth of section 2, a well gave this record:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-100	drift	Pleistocene
		Devonian
100-120	limestone	Cedar Valley
ends in shale		

This well is four miles north of the outcrops of Independence shale in the valley of Lime Creek described by Norton³⁵ and Thoms.³⁶

A well in Washington township has this record:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-72	limestone	Cedar Valley
ends in "soapstone"		Independence

This well is one mile east of the discovery pit at Independence. In the same section another well has this log:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-20	drift	Pleistocene
		Devonian
20-156	limestone	Cedar Valley
156-196	gritless clay	Independence
flinty rock at base		Davenport

In Linn county there are numerous shallow wells which show shale below the Cedar Valley. A few records are given here. One mile south of Lafayette is the J. Maier well. It showed:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-3	soil	
3-74	limestone	Cedar Valley
74-89	soapstone	Independence
89-92	sandstone	Independence

It should be noted that well drillers usually designate shale as "soapstone." This well is also within a mile of the locality where fossiliferous Independence shale can be seen in place

³⁵ Norton, W. H.: 1920, Iowa Geol. Jour., vol. 27, p. 388.

³⁶ Thomas, A. O.: 1920, Iowa Acad. Sci. Proc., vol. 26, p. 485.

below Cedar Valley and above Davenport limestone on East Otter creek. The F. P. Kratzer well is one and a half miles northwest of Lafayette:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-120	limestone	Cedar Valley
120-124	shale	Independence

This well is within a mile of the place where shale was collected from beneath Cedar Valley. The O. Gilchrist well, one-half mile south of Paris, shows this section:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-9	drift	Pleistocene
9-47	limestone	Cedar Valley
blue shale and a little coal at bottom		Independence

The W. D. Bucklin well is three miles west of Paris and has this log:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-20	soil and clay	Pleistocene
20-140	limestone	Cedar Valley
dark shale at bottom		Independence

The C. Rake well is a half mile south of Palo and two miles south of the outcrop of Independence on Little Bear creek. It shows:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-10	soil	
10-33	sand	Pleistocene
33-63	yellow and blue clay	Pleistocene
63-83	limestone	Cedar Valley
83-98	shale	Independence

The T. C. Martin well is two miles south of Fairfax where shale was uncovered below the bottom layers of Cedar Valley limestone in a recent quarry.

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-40	yellow clay	Pleistocene
40-90	hard fossiliferous limestone	Cedar Valley
soapstone and sandstone at bottom		Independence

In Johnson county the Mrs. Morris well three miles east and two miles north of North Liberty shows this section:

<i>Depth</i>	<i>Material</i>	<i>Formation and Age</i>
0-40	yellow clay	
40-42	sand	
42-92	blue clay	Pleistocene
92-94	sand	Pleistocene
		Devonian
94-204	blue limestone	Cedar Valley
204-212	shale	Independence
212-226	white porous rock	Davenport

It is readily admitted that these shallow well records may be questionable evidence, in the opinion of some geologists, regarding the stratigraphic position of the Independence shale. Yet these records may be of considerable importance, especially when reinforced by the facts yielded by the artificial and natural exposures in the near vicinities of the wells.

(To be continued.)