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THE INDEPENDENCE SHALE NEAR BRANDON, IOWA

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On June 23, 1876, at the first annual meeting of the Iowa Academy of Science at Iowa City, Prof. Samuel Calvin read a paper entitled "Preliminary Notice of Some Dark Shales near Independence, Iowa." The paper was not published but early in 1877 an abstract of it appeared in the American Naturalist, Vol. 11, pp. 57-58. In this abstract the shale is referred to the Marcellus due to its position below certain limestones, then believed to be Hamilton, and due also to the presence of a shell presumably of Marcellus age. The shale had been discovered in the bottom of a more or less temporary quarry by Mr. D. S. Deering, one of Professor Calvin's students.

Calvin's more complete description[1] of the shale and its unique fauna appeared the next year. From this we infer that the shales were stratified and undisturbed while "In some of the beds are numerous remains of plants." Later, in the Buchanan county report, Calvin states that in "shafts sunk at the Kilduff quarry, ... the formation was penetrated to a depth of twenty feet and was found to consist of dark-colored shales, alternating with beds of limestone."[2] On page 229 of the same report Calvin adds that "It was in an abandoned pit a few rods west of the O'Toole (Kilduff) quarry, that the first shaft which brought to light the Independence shales of this locality was put down." Thus it will be seen that the earliest knowledge of this terrane and its fossils was gathered from artificial exposures which in a few years were completely covered up. From these exposures and supported by evidence acquired by a little digging, Calvin constructed a section of the Devonian rocks of Buchanan county placing the Independence shale below the Gyroceras beds.[3] The failure of the shales with their easily recognized fossils to appear in many places at this horizon in other counties along the eastern border of the Iowa Devonian belt has led workers—and correctly—to refer stratigraphically equivalent terranes, even though barren and lithologically different, to

[1] Bull. U. S. Geol. Geogr. Survey Terr., IV, pp. 725-730, 1878.
[2] Iowa Geol. Survey, Vol. VI, p. 222, 1898.
[3] Amer. Geologist, Vol. VIII, pp. 142-145, 1891; also Vol. IX, p. 359, 1892.

the Independence. A well-known example is the Kenwood beds of Norton[4] in Linn county.

The fossiliferous facies of the formation has unfortunately been too meagerly known. Some years ago a typical Independence fossil, *Douvillina arcuata,* was brought up among well borings from a depth of one hundred feet near Walker.[5] Other borings have encountered shaly carbonaceous strata, believed to be the Independence from their position beneath the limestones. These finds, together with an outcrop that was soon covered by slump near Linn Junction found by Professor Norton several years ago,[6] prove that the dark facies has a fairly wide but perhaps irregular distribution. In spite of the readiness with which the unindurated shale slumps and is covered up it has been hoped that sooner or later natural exposures would be found. Fortunately a number of such outcrops occupying anomalous stratigraphic positions have been discovered.

In 1916-17, Mr. Merrill A. Stainbrook, one of the writer's pupils in historical geology, discovered a fossiliferous shale along Lime creek,[7] a tributary of Cedar river in the southwest corner of Buchanan county. The fossils which he collected are typical Independence forms. In company with Mr. Stainbrook, the writer visited the outcrop in the fall of 1917. Since that time the young man has found two other exposures which he reported by letter just before leaving for training camp. Later the three outcrops were studied in company with Professor Norton, of Cornell College.

Exposure No. 1.—Here the shale occurs in a sharp bend or reentrant on the right bank of the creek in the northwest quarter of section 26, about a mile northeast of the town of Brandon. Undercutting by the stream at this point has exposed from one to six feet of the shale for a distance of fifty to sixty feet. By digging back the sod above the shale the latter was traced about five feet higher up the bank, making a total thickness above the water of at least eleven feet. The digging, however, afforded no clue to the indurated beds, if any, which may overlie the shale at this point. The immediate bank of the stream here is close to twenty feet high while back from this the surface rises gradually to a height of nearly sixty feet. The outcrop is flanked by exposures of limestone; on the downstream side the shale and limestone are separated by about three feet of weathered shale intermingled with blocks and fragments of lime-

[4] Iowa Geol. Survey, Vol. IV, pp. 156, 157, 1895.
[5] Iowa Geol. Survey Vol. IV, p. 157, 1895.
[6] Private communication.
[7] This fifteen mile tributary of Cedar river is not to be confused with a stream of the same name in Cerro Gordo and Floyd counties. It is along the latter that the Lime Creek shale, mentioned later in this article, is found.

stone. For some twenty yards below this point the limestone is arched up into a low anticline and is considerably broken and jointed. This limestone contains Cedar Valley fossils characteristic of the lower part of that terrane. On the upstream side for a short distance the bank of the stream is sodded over. Still farther upstream the low limestone ledges are more weathered than in the anticline below and contain Cedar Valley fossils similar to those found back of the cemetery a half mile or more downstream.

The shale is dark bluish to gray in color, plastic and where weathered is yellowish with reddish streaks. It shows no bedding but there are occasional small blocks that show faint lamination and in some cases smoothed and slicken-sided faces. Irregular blocks of a harder, tougher, and more calcareous shale occur and there are also small nodules of pyrite and angular blocks of hard limestone. Fossils are fairly common and typical; to some of them cling crystals of pyrite as is the case with some of the fossils collected by Calvin and Deering at Independence. In the bend of the stream's bed and almost in contact with the shale is a large block of Lower Davenport limestone showing the characteristic brecciation and other unmistakable features of that formation. The block is angular, is three by five feet in dimensions, and is larger than any handled by the stream in flood. No exposures of the Lower Davenport are known up the valley. We must conclude that the block is intimately associated with the shale and is of the same derivation as the smaller angular limestone pieces incorporated in it.

Exposure No. 2.—This exposure is on the left bank of Lime creek a few rods down stream from No. 1 and near the south line of the northwest quarter of section 26. The bank of the creek here is flanked by a low ledge of limestone, a gap in which makes a sloping declivity for a distance of three or four rods. This slope is much trampled by cattle which use it as an approach to the water. At three or four places in this gap the shale is exposed, chiefly near the water's edge, but at one point near the upstream end the shale can be traced up the acclivity for six or seven feet. Digging exposed a width of nearly as much. At this point, too, the shale and limestone are separated laterally in much the same way as at the downstream end of Exposure No. 1 except that the zone of coarse material between them is narrower. Both the shale and the adjacent horizontally lying limestone pass beneath the drift.

The shale is gray, tough and plastic; it is unstratified and contains blocks of tougher clay and angular fragments of limestone.

Doctor Norton recognized some of them as blocks of the Otis calcilutite. Fossils are few but typical.

Exposure No. 3.—This outcrop is in Benton county on the left bank of Cedar river in the northwest quarter of section 9, township 86 north, range 10 west, and is about two miles south and one mile west of Brandon. The shale occurs in a re-entrant near the north end of a precipitous cliff close to fifty feet high, called by Savage,[8] in his Benton county report, the Cedar river section. To the north across a ravine is Long's quarry—both exposures are Cedar valley limestone. In the re-entrant among the tumbled blocks of limestone occurs the shale with its characteristic fossils. Three or four feet of the shale are exposed at a height of about ten feet above the water and separated from it by a gentle talus slope fifteen to twenty feet wide. The re-entrant is twenty-five to thirty feet wide and becomes wider within where its walls are largely joint faces in the limestone away from which the rock has slipped toward the opening due to sapping. The material from this large well or cistern-like hollow in slipping out has encroached on the shoreline in the form of a small talus delta. Within the "well" the talus rises away from the opening to the top of the cliff with a slope so steep as to be climbed with difficulty. The rock in the walls of the "well" are practically horizontal and but little disturbed. Between this exposure and the ravine to the north, however, there is evidence of considerable disturbance. Faulting here has brought up brecciated Davenport beds almost to the top of the cliff. The position of the ravine itself suggests a line of weakness. Brecciated blocks lying at all angles, slicken-sided faces, distorted and obscure bedding, and joints and fractures are some of the features which testify to the stresses which accompanied the displacement. Moreover, the rocks in the disturbed section are practically barren in comparison with the very fossiliferous Cedar Valley beds a few yards to the south as well as to the north across the ravine in Long's quarry.

Summarizing the three exposures of the shale we may note that they are alike in that they abut laterally against Cedar Valley limestone; in that the overlying beds are absent or unexposed, as far as could be determined, while the underlying strata at each place are inaccessible; in that each is a sort of shale breccia containing an admixture of blocks and fragments of sub-Cedar Valley limestones; and in that each carries the typical Independence fossils.

[8]Iowa Geol. Survey, Vol. XV, pp. 180, 181, 1905.

A list of the more common species collected at the three localities may be of interest. The brachiopods greatly predominate.

Zaphrentis sp.
Macgeea solitaria (H. & W.).
Orthis (Dalmanella) infera Calvin.
Schizophoria cf. *striatula* (Schlotheim).
Stropheodonta calvini S. A. M.
Strophonella reversa Hall.
Leptostrophia cf. *canace* (H. & W.).
Douvillina arcuata (Hall).
Douvillina variabilis (Calvin).
Productella hallana Walcott.
Strophalosia n. s.
Hypothyridina cuboides (Sowerby).
Atrypa reticularis (Linne).
Atrypa hystrix Hall.
Spirifer sp.
Martinia subumbona (Hall).
Cyrtina n. s.
Crinoid stems.
Plate of crinoid.
Tentaculites sp.
Ostracoda (undet.).

The low monoclinal dip of the Paleozoic strata of Iowa is to the southwest and amounts to ten to fifteen feet per mile. The Brandon exposures of the Independence shale are twelve to fifteen miles southwest of the artificial exposures at and near the O'Toole quarry. According to an unpublished topographic map of Iowa by Dr. James H. Lees, the altitudes of the Brandon and Independence exposures are each close to 900 feet above sea level. Hence, at Brandon, other things being equal, the Independence shale should be at least 125 feet below the surface. Its anomalous occurrence on a level with the basal Cedar Valley may be explained: (1) as a local unconformity in which the Lower and Upper Davenport beds are wanting and with the Cedar Valley resting on the Independence shale; (2) as a post-Cedar Valley deposit laid down in the erosion hollows or other depressions in its surface; (3) as a filling thrust up into irregular openings in the Cedar Valley at the time of the brecciation of the lower Devonian terranes.

A brief discussion of the three hypotheses brings out (1), at Independence only fifteen miles away the Davenport beds occur with-

out a break below the Cedar Valley and at all other points where the basal beds of the Cedar Valley are exposed there is no erosion contact between them and the subjacent beds. Granted that the Brandon contact is an erosional unconformity, it would seem strange that the resistant Davenport beds should be entirely removed, leaving the relatively unresistant shale in the form of steep-sided remnants as we have it at each of the three exposures. Moreover, the shale must have been lifted by an upwarp of 125 feet to bring about the relations indicated; (2) the fact that the Sweetland Creek and State Quarry lie unconformably in depressions in the Cedar Valley and the additional fact that certain resemblances exist between the faunas of the Independence and Lime Creek shales lend plausibility to the view that the Independence shale deposits are remnants of a formerly wider distribution of the Lime Creek. Against this view it should be pointed out that where the Lime Creek shales are typically developed, as in Cerro Gordo, Floyd and Butler counties, the fossiliferous part of the Lime Creek—at least that part containing the Independence-like fauna—is underlain by scores of feet of relatively barren plastic shales and these in turn are separated from the Cedar Valley by the Nora limestone[9] which in places is twenty feet thick. It would seem that some part of the Nora or of the plastic blue shale should fill a part or all of these depressions rather than they should be filled with the fossiliferous shale occurring below the Owen limestone near the top of the Lime Creek section. The fossils of the Independence, when they are critically studied, are seen to be quite distinct from these of the Lime Creek. It is true that a few species, such as *Strophonella reversa, Douvillina arcuata, Atrypa reticularis, A. hystrix, Macgeea solitaria,* and possibly a few others occur in both formations. A brief study, however, enables one to distinguish those from either formation readily. The Independence species are invariably smaller and there are other differences. *Stropheodonta calvini* and *Douvillina variabilis* are the commonest species in the Independence—the forms which have gone under these names from the Lime Creek are specifically distinct from them and the same is true of some others. Moreover, the index fossils of the marly shales of the Lime Creek, *Spirifer hungerfordi, S. crestes* and *S. whitneyi* do not occur in the Independence, while the common little *Orthis* (*Dalmanella*) *infera* and the rarer *Gypidula munda* as well as the atypical *Martinia subumbona* have no representives in the Lime Creek. Other equally striking absences and differences could be given but the instances cited are sufficient to confirm

[9]Science, n. s. Vol. XXXVI, 1912, pp. 569, 570.

the usual opinion that the Lime Creek fauna is a greatly expanded and recurrent descendant of the Independence rather than a contemporary; (3) the brecciation of the lower Devonian terranes of Iowa has had a profound effect on their structure. Minor folds, flexures, distortion, obscured bedding, small faults with throws from a few inches to a score of feet or more, together with the cracking and breaking of the rock into angular fragments of all sizes are some of the features resulting from the stresses to which these terranes were subjected. The shaly portions of the Independence beds being plastic and incompetent under the strain were evidently squeezed up into crevices, pipes, and under arches. At exposures Nos. 1 and 2 the limestones are considerably flexured, broken and displaced. All along Lime creek in the vicinity of Brandon "the beds are folded, buckled and displaced on a scale sufficient to produce a complex series of alternations of lithological and paleontological characters at the same level along the hillside."[10] The prominent fault near exposure No. 3, the angular blocks of Lower Davenport and Otis limestones mixed throughout the shale at each exposure, the lack of bedding and continuity, and their anomalous position abutting against Cedar Valley limestones, all point to the reasonable conclusion that the shales have been forced up into their present position at the Brandon exposures by the forces which produced the brecciation. It is not urged from this that the shales have everywhere been so squeezed out of their natural position, in fact Calvin[11] calls attention to the point that the overlying Gyroceras beds at Kilduff's quarry are undisturbed and it is inferred from his note that the shales below, at this place, are also stratified and "alternating with beds of limestone" as quoted earlier in this paper.

In closing the writer wishes to acknowledge the valuable suggestions of Dr. William H. Norton with whom the outcrops were studied in the field. The conclusions arrived at are a result of this conference and to Doctor Norton, whose critical study of the brecciation of the Iowa Devonian is well known, should be given special credit for the suggestion that the present position of the shale at each outcrop is a result of the squeezing accompanying brecciation.

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[10]Calvin, Iowa Geol. Surv. Vol. VIII, 1898, p. 238.
[11]Amer. Geol., Vol. IX, 1892, p. 359.