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Controlling Fault Systems in Iowa

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CONTROLLING FAULT SYSTEMS IN IOWA.

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With its even plains surface, the infrequency of bed-rock exposures, and the universal presence of thick till or loess mantles, detailed geologic mapping of the prairie states is attended by many inherent difficulties not met with in more broken country. In consequence of the existence of these unusual conditions the consideration of possible noteworthy geotectonic features in the region is largely neglected. Anything beyond a few of the most obvious local characters completely fail of record. Over a very large part of the Mississippi basin the tectonics are commonly treated as if there were none at all. It seems to suffice to regard the strata as essentially flat-lying and as having no pretense to deformation of any kind. In Iowa, for instance, beyond the general assertion that the foundation rocks dip gently to the southwest no further note is made of the local or broader tectonic characters.

Lately, both in our own state and in neighboring states, the neglected problems in regional tectonics have been attacked from new and unexpected quarters. Novel data have been obtained. Long known but isolated facts have been reviewed, reinterpreted, and recorrelated. The trend of most fruitful inquiry has been pointed out. In Iowa, especially, results quite surprising have been reached. Attention already has been directed[1] to the Triassic mountain-building which took place within our boundaries. Particular interest also attaches to the recent determination[2] of the distinct synclinorial character of the Iowa coal basin. Now note must be made of another instructive phase of the regional tectonics and the discovery of what appears to be two well-defined systems of faulting on a large scale that has heretofore eluded detection.

The lines of faulting of the two systems trend nearly at right angles to each other. In the system which prevails in the eastern part of the state the direction of fracture is northwest and

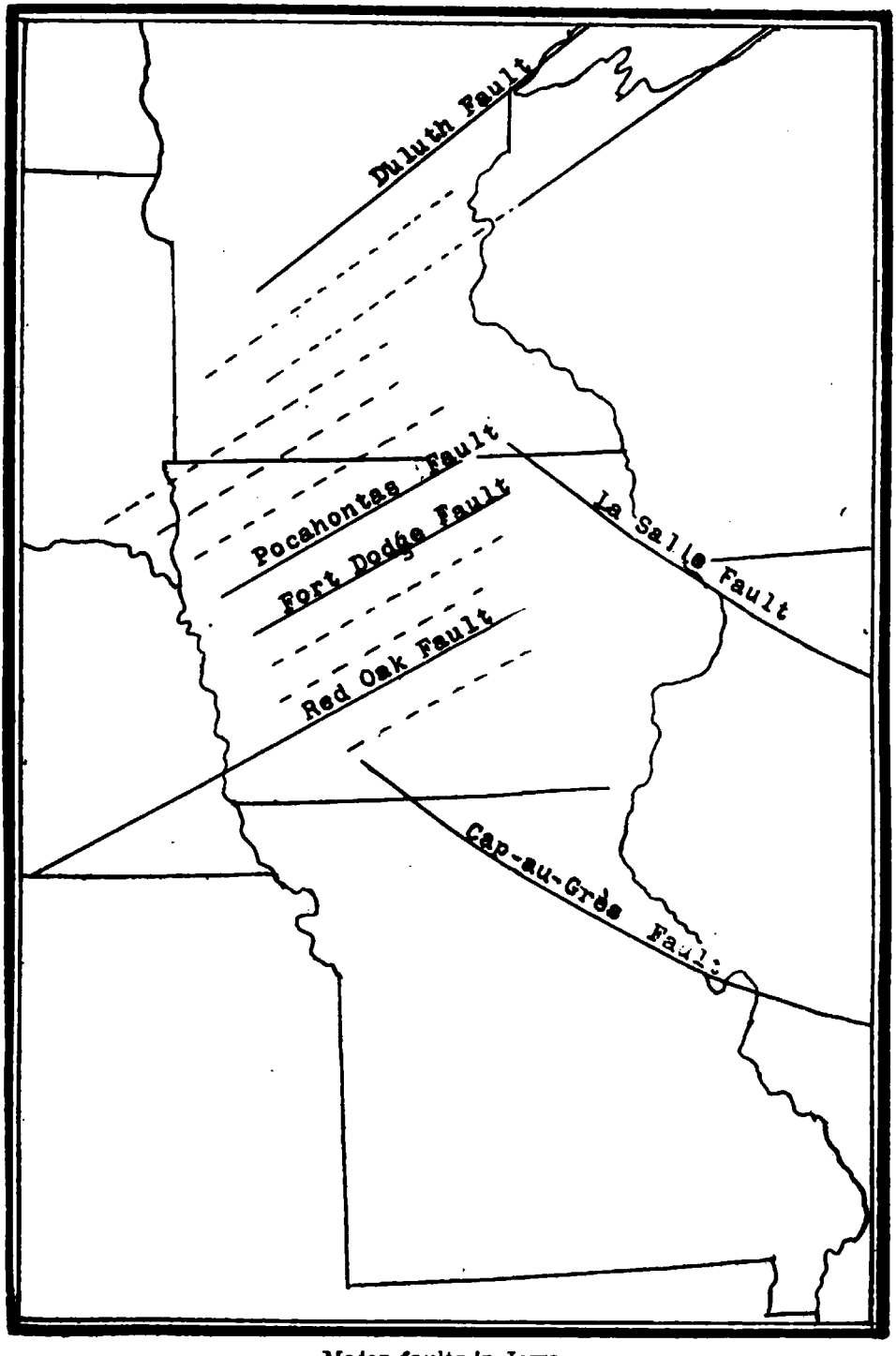
[1]Proc. Iowa Acad. Sci., Vol. XXI, 1914, p. 181.
[2]Ibid., Vol. XXII, 1915, p. 268.

southeast. The amount of displacement is large. The spacing is wide. The ruptures are long and somewhat curved. In the other system, which is confined to the western portion of the state, the value of the movement figures is not nearly so great as in the case of the other; yet it is still quite notable. The space beween successive faults represents a distance of about twenty-five miles. Both systems of faults appear to have greater displacement values outside of the state and to vanish within the boundaries of our commonwealth. The faults extend laterally far into neighboring states. (Plate IV.)

At this time it is not necessary to go exhaustively into descriptive details concerning the individual faults, since these features are in another connection subject of extended discussion. The most conspicuous of the displacements is the Cap-au-Gres fault. It is the most notable line of recent dislocation found anywhere in the Mississippi valley. Its salient features are best displayed on the Mississippi river near the mouth of the Illinois river. The sandstone headland which marks its position there has been a prominent landmark to early *voyageurs* and rivermen for a period of more than two and a half centuries. The upturned edges of the strata constitute one of the most extensive and complete geological sections on the continent. Within a distance of one short mile along the river bluff, at Folley station, the entire Paleozoic succession, from Cambric dolomites to Coal Measures, is exposed. Measurements indicate a vertical displacement of more than 1,000 feet. So admirably are the disturbed rocks displayed that a photographic print of the bluff clearly retains all the structural features.[3]

The line of the Cap-au-Grès rupture extends from Leon, in southern Iowa, to Vincennes, Indiana, a distance of 400 miles. At its eastern extremity the fault passes into a fold, probably of monoclinal rather than anticlinal character, that gives rise to the great oil reservoir of eastern Illinois and western Indiana. The western extension likewise passes into a fold which furnishes the most favorable conditions in our entire state for the occurrence of oil and gas. At the southern boundary of Iowa the line of this fault is conspicuously marked on the surface of the ground by a long eastward protrusion of the Bethany limestone, the basal terrane of the Missourian series. This tongue carries the Bethany formation a distance of fifty miles beyond

[3]See Proc. Iowa Acad. Sci., Vol. V, 1898, p. 58.



Major faults in Iowa.

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its normal eastern boundary as usually mapped. As it enters Iowa the Cap-au-Grès fault has a displacement of 100 feet, so that here it is still a fracture of considerable moment.

Another notable fault-line, which merits fuller investigation than has been heretofore accorded it and about which so far as Iowa is concerned relatively little is yet definitely known, exists near Dubuque. It has a throw of fifty to seventy-five feet. One reason for its not being better understood doubtless is the fact of its position for many miles in the channel of the Mississippi river. According to the maps of Illinois this fault-line appears to be really the northwestern extension of the great La Salle fault, which at the town of La Salle has a displacement of quite 1,000 feet. Illinois geologists claim that the La Salle fault has a north and south trend; but the geological maps of the region clearly indicate otherwise, and many other recorded facts fully corroborate the testimony of the maps.

Between these two great fault-lines are several rather sharp folds which may pass elsewhere into faults. None of these has been examined yet in detail. They may prove to be regularly spaced and thus form a part of a definite fault system.

It is, however, to the remarkable fault system of the western part of the state that attention is here especially directed. Two faults in particular merit full notice at this time because of the fact that their discovery necessitates extensive rectification of geologic boundaries. There are, also, economic bearings which are of great local importance. The two most instructive ruptures of this western system are the ones passing near Red Oak and near Fort Dodge.

For such a profound fracture, with its maximum displacement of not less than 400 feet, the Red Oak fault makes singularly inconsequential impress upon the local relief expression. In one direction it appears to extend beyond the city of Des Moines; in the other to Hebron, Nebraska—a distance of 300 miles. Its features are best displayed at its crossing of the Missouri river, at Wyoming, a short distance above Nebraska City. When the disturbance was first noted at this point it was thought to represent a sharp monoclinal fold; and it was so interpreted by Professor J. E. Todd.[4] Later investigation on the Iowa side of the river, near Truman, showed that there was

[4]Proc. Iowa Acad. Sci., Vol. I, 1890, p. 58.

practically no tilting of the strata, but that the lower beds on the north side of a given point abutted higher layers of the south side.

The detection of this notable fault-line fully explains why, during the attempt to map geologically Montgomery county, the Cretacic formations were so well exposed throughout the southern half of the county, but were apparently entirely absent in the northern part. Planation had entirely removed the higher Mesozoic beds on the north, but had not touched those to the south, where they were deeply depressed and thus escaped obliteration. Another hitherto inexplicable fact, which now appears to be satisfactorily cleared, is the abrupt change of lithologic character which has been long known in the Des Moines river section a few miles north of the city of Des Moines. For more than a generation this had been one of the most perplexing problems in Iowa geology.

The Fort Dodge fault is particularly noteworthy because of the fact that to it the great Iowa gypsum field directly owes its preservation; and important chalk deposits exist as outliers eighty miles east of their normal outcrops. As recently acquired the details on this dislocation are unusually full and may be with advantage summed up here. They are all displayed in an exceptionally clear manner within the limits of the city of Fort Dodge.

The abrupt termination of the thick gypsum bed at the Cummings quarry, in the south bluff of Soldier creek, in north Fort Dodge, and its replacement at the same level on the north side of the narrow valley by the St. Louis limestone and coal measures calls at once for a more critical examination of the causes therefor than has been hitherto given to the phenomena. In this district there is a general rising of the limestone towards the north; but in the same direction a marked falling of the gypsum. At the mouth of Soldier creek the gypsum layer comes down to a level below that of the creek bed. It is this fact mainly that has in the past given rise to the inference that the gypsum finally rests directly upon the limestone, especially since the latter crops out in the banks of the creek and in the ravines within a distance of a few hundred yards beyond the last known gypsum exposure.

About three-fourths of a mile upstream from the Cummings locality, in Soldier valley, near the new brick plant, several es-

pecially instructive exposures are now displayed. The valley here is quite deep and narrow. There are, on one side of the creek, the ruins of an old lime-kiln. The St. Louis limestone, which was formerly quarried at this point to supply the kiln, rises about twenty feet above the bed of the stream. Two hundred feet to the southeast, in another bend of the creek, the gypsum plate, overlain by thirty to forty feet of reddish, sandy shale, outcrops at water-level. Northwest of the lime-kiln, about 400 feet, on the opposite side of the Soldier gorge, in the clay pit of the brick plant, forty feet of coal measures are well displayed. It seems hardly possible that the gypsum-plate, here twenty-five feet in thickness, should wedge out abruptly and completely in so short a distance.

The most illuminating section of all in the entire region is that at the south end of the long narrow ridge which separates Soldier valley from that of the Des Moines river. Two exceptionally fine artificial exposures supplement the natural outcroppings of strata. On the one side of the ridge the excavation for one of the abutments for the country highway viaduct over the Soldier gorge discloses, in fresh, clean face, over seventy-five feet of the pink shales which immediately overlie the gypsum. The latter lies in the bed of the creek a short distance away. The Kohl Brewery section is near by, although now nearly completely obscured by talus. The two sections, which are easily matched by the sandstone ledges, together give the following sequence:

SECTION AT LOWER VIADUCT OVER SOLDIER CREEK.

		Feet
8.	Till, gray and pebbly	10
7.	Shale, light reddish, sandy, banded	35
6.	Sandstone, soft, buff, calcareous, massive	5
5.	Shale, pink and white, sandy, in alternate layers	25
4.	Sandstone, massive, buff	2
3.	Shale, bluish	2
2.	Shale, brown, sandy, with gypsum layers	7
1.	Gypsum, massive (exposed)	10

This exposure is the most extensive one of the pink shales yet disclosed. The thickness of the latter is therefore at least 100 feet.

On the opposite, or north side of the high ridge, is the huge open clay pit of the Fort Dodge Brick and Tile Company. The

bottom of the excavation is nearly, if not quite, down to the St. Louis formation; and is about thirty feet above the level of the water in the Des Moines river near by. Fully seventy feet of shale are exposed in clean section, which presents the following sequence of beds:

SECTION AT CLAY-PIT OF FORT DODGE BRICK AND TILE PLANT.

		Feet
9.	Till, ashen, with pebble bands	15
8.	Shale, blue, yellow and variegated	18
7.	Sandstone, gray, massive	2
6.	Shale, black and gray, with coal-seams	11
5.	Shale, white (fire-clay)	2
4.	Shale, light-colored and variegated	15
3.	Shale, dark-colored, partly hidden at base	25
2.	Sandstone, coarse, conglomeratic, ferruginous	1
1.	Limestone, gray	30

In cross-section, the ridge appears as represented below (figure 6), in which the gypsum-plate is noted to lie about thirty feet beneath the level of the top of the adjoining St. Louis lime-

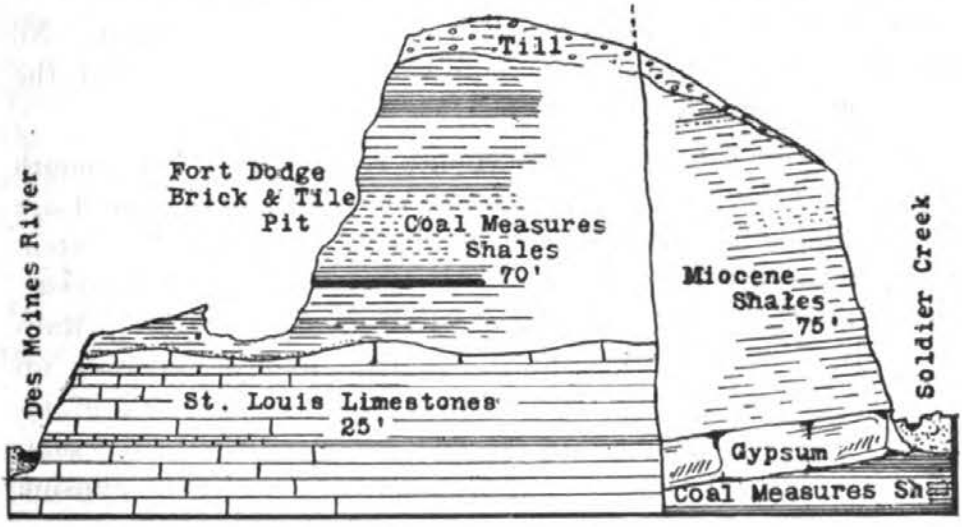

Fig. 6—Details of Fort Dodge fault.

stone, and nearly one hundred feet beneath the top of the coal measures of the clay-pit. In stratigraphic level there is thus a discrepancy of more than one hundred feet between corresponding parts on the two sides of the ridge.

On the west face of the ridge, in a railway cutting, near a point where on the same level the pink shales appear to be abruptly replaced by the dark shales of the coal measures, an inconsequential faulting of the first mentioned beds is plainly

discernible. This slight fault has a throw of about six feet. It is suggestive of the possibility of the greater displacement being of the distributive order instead of being a single simple break in the stratigraphic continuity.

At the old stone wagon bridge over Soldier creek, one-half mile above the lower viaduct, and immediately north of the Rock Island railway station, there is a singular physiographic suggestion of notable faulting. For a distance of several miles before reaching this bridge the creek flows in a deep, narrow gorge. At the point where the bridge spans the waterway the latter cuts sharply into the hard St. Louis limestone, so as to form a small canyon thirty feet wide and twenty feet in depth. The abutments of the bridge are the two walls of the canyon. Less than one hundred yards below the bridge the limestone, although standing thirty feet above the creek bed, abruptly disappears. The Soldier gorge opens out into a broad, flat-bottomed amphitheatre a thousand feet wide and half a mile long, the flat forming an area sufficiently ample for utilization by the railroad for its local yard purposes. The amphitheatre is excavated entirely in the friable sandy shales which overlie the gypsum. No sign of the St. Louis limestone is to be seen save the point on the north side where the creek debouches from its canyon.

On the west side of the Des Moines river, opposite the mouth of Soldier creek, new and important data of an exact kind are now available bearing upon the points in question. The extensive excavations of the Fort Dodge Clay Works, the construction of the Omaha extension of the Chicago Great Western Railway, the drilling of numerous deep wells, and the opening up to inspection of many other sections, disclose a number of instructive facts which supply the long missing links in the solution of the gypsum puzzle. On this side of the river the gypsum plate retains the same gentle slope to the northward, as it does on the east side of the stream.

It is shown by drill-holes and by excavations that the gypsum bed, fifteen to twenty feet in thickness, lies between seventy-five and ninety feet beneath the upland prairie surface. This overburden is composed chiefly of glacial till. Beneath the gypsum layer are sixty to eighty feet of shale—the coal measures; then the St. Louis limestone. The great thickness of the shale section carries the limestone a considerable distance beneath the level of the water in the Des Moines river, a mile and a half

below the mouth of Lizard creek and half a mile below the mouth of Soldier creek. Yet at the mouth of the Lizard the limestone is abruptly encountered seventy feet above the water-level. It is an early observation of C. A. White and others that no outcrops of gypsum occur for some little distance below the mouth of Lizard creek; it is also a matter of early record that southward beyond the points just mentioned the gypsum suddenly appears in outcrop well up in the bluffs. For these anomalies there has never been any adequate explanation offered. As appears farther on, these features, together with others, conclusively point to either abrupt flexing of the strata, or notable dislocation in the continuity of the layers. Either suggestion is a wholly unexpected phenomenon in this district. In a region such as Iowa, where there is seemingly so little orogenic disturbance, neither sharp folding nor extensive faulting is ever appealed to. However, several extensive breaks in the Iowa rocks are now known; and other geotectonic features come to light which give this phase of the State's geology a new trend.

On the geologic map of Webster county,[5] the nearly straight line which the north margin of the gypsum-bearing field makes is in itself suggestive of structural rather than erosional causes. This aspect of the areal limits was not thought of at the time the map was drawn. The fact of its location shows how accurately is the delineation notwithstanding the circumstance that the reason thereof was unknown.

As shown by outcrops and numerous well-sections located near this line on either side, there is a marked discordance in the meeting or matching of the various strata.

As already indicated, the amount of displacement at the intersection with the Des Moines river is not less than 100 feet. This may or may not be the maximum throw; probably it is not. Several features point to a greater development of the fault towards the southwest.

The length of this great rent in the earth's crust is not yet with accuracy determined. That it extends from Clarion, in Wright county, to Wall Lake, in Sac county, a distance of eighty miles, seems certain. That it is traceable beyond these points is quite probable. It is safe to say that this fault is not less than a hundred miles long.

[5] Iowa Geol. Surv., Vol. XII, 1902, p. 192.

With the recognition of this fault-line a host of features relating to the distribution of the formations of the region, hitherto puzzling or uncertain of determination, are fully explained.

North of Fort Dodge there are evidences of another fault which passes through Pocahontas and which has a throw of about eighty feet. The horizontal distance between the two lines of displacement is approximately twenty-five miles. This figure suggests the spacing value of the whole system. Plotting upon the map of the state other lines to mark possible positions of other faults we find abundant indications of the presence of such features. One of these passing a short distance south of Ames points to the isolated protrusion of Early Carbonic limestones being really produced by differential movement along a line of rupture.

It is a well known fact established through extensive experience in mining operations that when the interval between two parallel faults is determined that other faults are to be expected at like intervals. This circumstance is traceable directly to the nature of the tortional strains which rock-masses undergo. Whether or not such a high spacing value as twenty-five miles is actually possible remains to be determined theoretically. The problem is readily susceptible of mathematical demonstration as in the cases of fault systems of much closer patterns as recently noted by G. F. Becker[6]; and it would be exceedingly instructive to apply the principles involved to the Iowa situation.

In any case the general geological mapping of the state requires fundamental rectification.

[6]Bull. Geol. Soc. America, Vol. IV, 1893, p. 13.