Note on Fault Structure in Indiana. By Geo. H. Ashley.

It has long been a prevalent idea with Indiana geologists that this State is practically without faults or fault structure. Prof. E. T. Cox, for many years State Geologist, says in his last report:* "Not a single true fault, or upward or downward break and displacement of the strata has yet been discovered." Prof. John Collett, so long a student of Indiana geology, says in describing Badger Bros.' mine in Sullivan County:† "An interesting feature of this mine was the discovery of a vertical dike or wall of inclusive clay, one foot wide, running a little east of north. This is the only fault, though here only a separation, that I have met with in the coals of Indiana," etc.

In view of such statements by the earlier workers, repeated by some of the more recent workers, it was not without surprise that the writer found that faults not only existed in the State, but were abundant and well exposed. It may be that this is truer of the coal measure area than of the rest of the State. Certain it is that the extensive mining of the coal gives a better opportunity for the study of these phenomena than is granted elsewhere, and further, the displacement of a coal bed is more readily noted when seen in a bluff or other exposure than a displacement in most other rocks.

The figures accompanying this note are selected from sketches and photographs made while engaged in a survey of the coal area of the State for the Department of Geology and Natural Resources. Time did not suffice for a detailed study of the faults, only such notes being obtained as were made incidental to the main work.

In a general way it may be said that the phenomena observed consist of normal faults, either single, double, wedge or step faults, sometimes accompanied with little or no notable crushing, or again accompanied by intense and extensive crushing, to be followed by the intrusion of clay or other substances; reversed or overthrust faults, crushed and thickened strata, due to tangential pressure, oblique jointing of strata due to the same cause, old surface crevices filled from above. Normal faults predominate, with down-throws varying from a few inches to forty feet or more. In number it may be judged from their abundance wherever extensive

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*1879. 8th, 9th and 10th Ann. Rep. Geol. Surv. of Ind., p. 3.

†1871. 2d Ann. Rep. Geol. Surv. of Ind., p. 205.

mining or good bluff exposures give an opportunity to observe them, that Indiana contains thousands of faults of appreciable down-throw. In some districts there is hardly a mine that does not contain from one or two to several dozen.

In their relation to the general structure the normal faults divide themselves into four classes, as typified in figures 1 to 4, plate I. In the first type, which might be called the monochinal fault, the fault is simply a fractured monocline, the down-throw of the fault usually not being as great as the differences of level above and below the monocline. Such a fault may consist of a single break or of two or more breaks, known as a step fault. In some cases the same fault will show as a single break at one point and as a step fault at another point, as in the case illustrated by figures 6 to 8 of plate I. Figures 5, 9 and 10 further illustrate the same type of fault.

In the second type of fault the hade is in the opposite direction from the general dip. Figures 11 to 13 of plate I illustrate this type of fault. Such a fault usually occurs as a series of breaks, resembling a broken arch, a type of fault common in the western part of the United States.

Faults of the two types mentioned constitute a class that appears to be due to the uneven settling of the Illinois basin area. These faults, taken as a whole, do not appear to have any uniformity in the direction of down-throw or of strike. However, if only the larger faults be considered, a majority of them trend between northeast and northwest and have the down-throw to the west. There are so many notable exceptions that it can not be considered as a rule. Thus, in Martin County, from Shoals westward, the dip is nearly everywhere observed to be strongly to the west, yet so many faults with the down-throw to the east occur in that region that the strata are higher five miles west of Shoals than at Shoals.

In the third and fourth types the faults appear to be due to quite local causes, as the strata a short distance on either side are on about the same level. Figure 14 of plate I and figure 2 of plate II illustrate the two types, respectively. The difference between the faults of the first two types and those of the last two are very well shown in the effect on the driving of entries in the mines. Thus, a six-foot fault of the first type necessitates driving the entry up or down until it is at least six feet above or below its old level, according as the fault is approached. A six-foot fault of the third type can be passed with little or no change of level in the entry. A possible cause of faults of the last two types is thought to be the unequal subsidence of underlying basins of coals. In a basin where, as is usually the rule. the coal is quite thick in the center and very thin on the edges, the actual shrinkage is much greater in the center of the basin than on the edges. A certain percentage of this shrinkage is known to take place after the deposition of the overlying beds. Where a channel has been cut in the coal and filled with sandstone an irregular belt results which resists compression much more than the coal adjacent and might lead to a fracturing of the overlying strata. as the subsequent unequal settling takes place. This is suggested merely as one possible cause of such faults. These faults are very irregular as regard course and direction of down-throw. frequently crossing each other. sometimes being very short and again traceable in two or more adjacent mines. In the Dugger Mine. Sullivan County, three faults cross each other in the same vertical line at one place.

Considering the structure of the faults at the fault line, it is found that frequently the fault line appears sharp and clear cut, as in most of the figures of plate I, and it is only on very close examination that any crushing can be detected. In other cases. however. the crushing effect has been intense for several feet. or even several yards. on either side of the fault line. This often occurs where the down-throw is hardly noticeable. At such a fault there is very apt to result an intrusion of clay or other material, making clay veins. sandstone veins, etc. Figures 3 to 9 of plate 11 illustrate this. The way the pressure has forced the clay out in irregular streamers, as in figures 3 and 4, or simply forced it into the coal in irregular masses, as in figure 5, give some idea of how completely pulverized the adjacent coal often is. The sandstone veins, or "rock spars." as they are usually called in the mines. are generally very hard sandstone. Apparently they are somewhat similar in origin with the clay veins. though we are not entirely satisfied that such is the case. In figure 14 a surface crevice has had coal washed in. making a coal vein of a certain type.

If such a crevice be considered as probably resulting from fault action in the neighborhood it would indicate that some of the faulting took place during the laying down of the coal measure rocks. This vein occurs about ten feet below the lowest worked coal in Indiana.

Overthrust faults and accompanying phenomena are not common, as compared with normal faults. They are met with in various parts of the field, but the amount of accompanying crushing often renders the structure

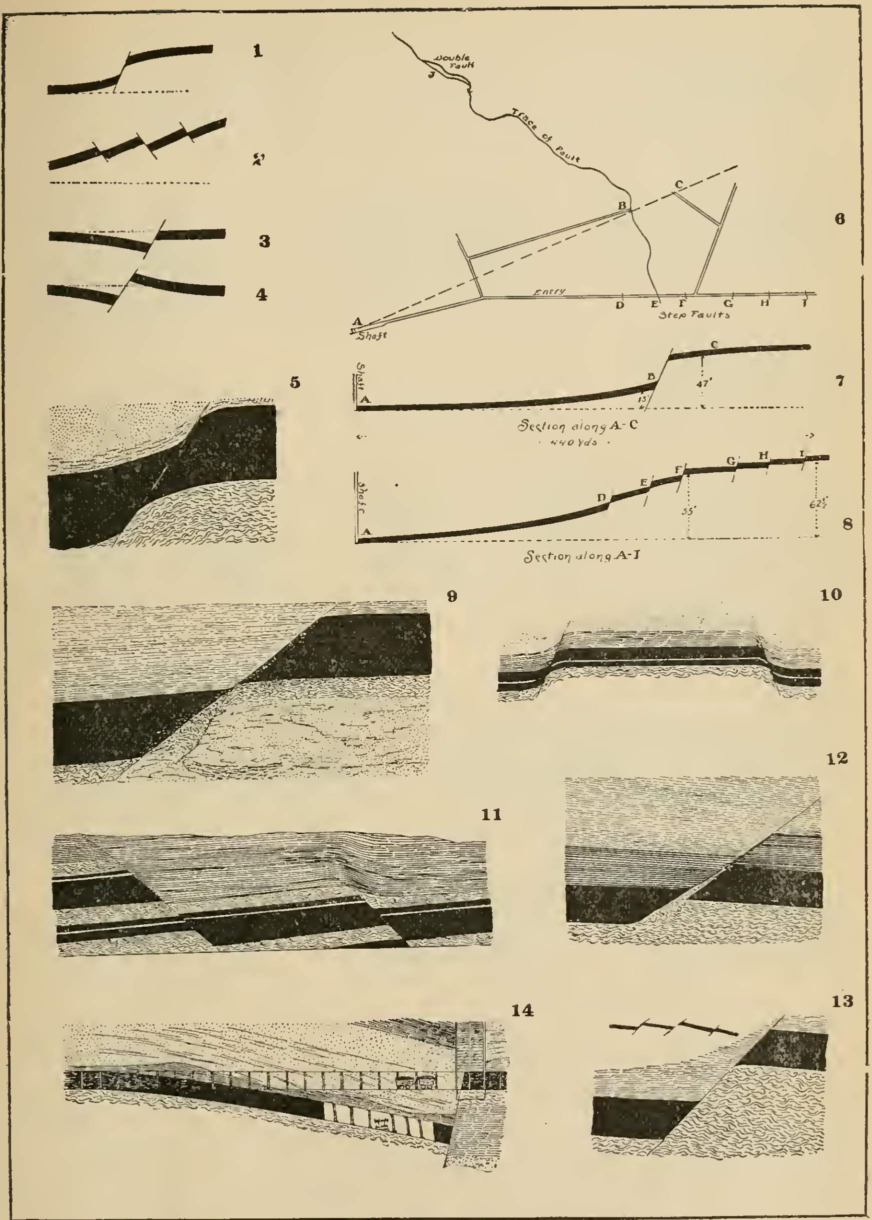
1
2
3
4
5
Double Fault
Trace of Fault
Entry
Step Faults
Shaft
6
Section along A-C
440 yds
7
Section along A-I
8
9
10
11
12
13
14

Plate I.

obscure and their study difficult. Illustrations of such faults are given in figures 11 to 13. In figure 13 the lower of two beds twenty feet apart has been forced an unknown distance over the upper bed. Some of the accompanying phenomena consist of oblique jointing, induced in the strata, and in the vertical thickening of coal beds, as illustrated in figure 10.

DESCRIPTION OF PLATES.

Plate I—Typical normal faults:

Fig. 1. Type of monoclinal fault. See figures 5 to 10 inclusive.
2. Broken arch type of fault. See figures 11 to 13, inclusive.
3. Type of fault shown in figure 14.
4. Type of fault shown in figure 2 of plate II.
5. Fault in Fairview Mine, Clay county.
6-8. Fault in B. B. C., Co.'s No. 10 Shaft. Map and sections.
9. Fault on Otter Creek, 3 miles north of Brazil. From photo.
10. Double fault in Peerless Mine, Vigo county.
11. Double fault on Big Vermillion River, near Hanging Rock.
12. Fault on north fork Otter Creek, near Coal Bluff, Vigo county.
13. One of series of faults in Fairview Mine.
14. Fault crossing shaft in Jackson Mine, Clay county.

Plate II—Irregularities due to faulting; clay, sandstone and coal veins; overthrust faults and crushed structure:

Fig. 1. Combined fault and "roll," Monarch Mine, Clay county.
2. Fault of type 4, Dugger Mine, Sullivan county.
3-4. Clay veins resulting from faults. P. Co. C. Co.'s No. 6 Shaft, Parke county.
5. Clay in old fault plane, Winsett Mine, Vermillion county.
6. Clay vein, Dugger Mine, 10 feet from and running parallel to large fault.
7. Sandstone vein, Ray Mine, Vigo County. Shows displacement in another entry.
8. Sandstone vein, Mecca No. 1 Mine, Parke county.
9. Sandstone vein, B. B. C. Co.'s No. 8 Mine, Clay county.
10. Showing structure of coal bed thickened to nearly four times normal thickness by lateral pressure, in region of overthrust faults, Columbia No. 3 Mine, Clay county.
11-12. Coal bed greatly disturbed, Lee's Mine, Vermillion county.
13. Overthrust fault, Columbia No. 4 Mine, Clay county.

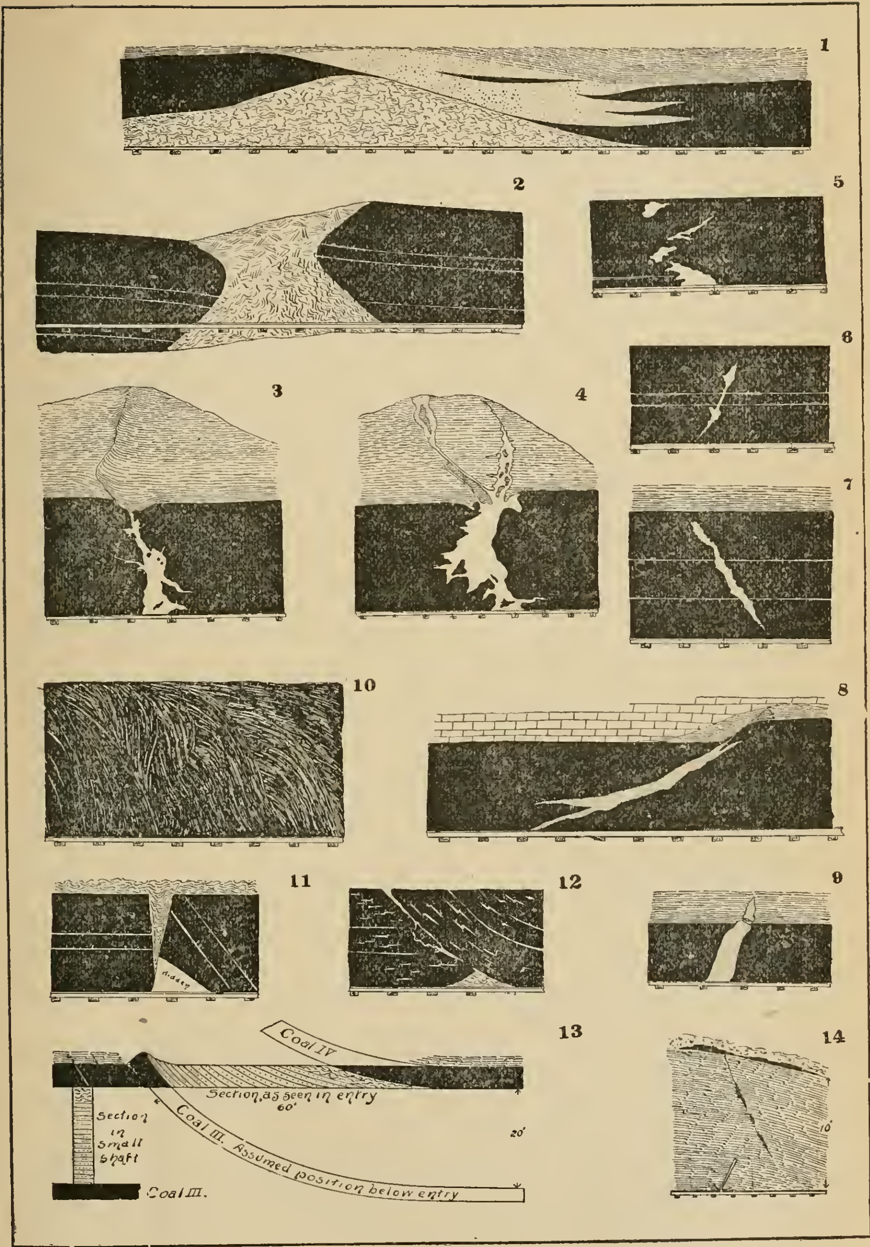
1
2
5
6
3
4
7
10
8
11
12
9
13
14
Coal IV
Section as seen in entry
60'
Section in small shaft
Coal III. Assumed position below entry
20'
Coal III.
10'

PLATE II.

14. Coal vein, Gart. No. 5 Mine, Clay county.

Figure 11 of plate I and figures 5, 11 and 12 of plate II are from sketches by Mr. E. M. Kindle, assistant on coal survey. With the exception of figures 1-4, 6-8, 10, 14, of plate I, and figures 13 and 14 of plate 11, all the figures are in the scale of 1 inch=10 feet.

As it was the writer's purpose in this paper merely to call attention to one of many interesting geological features of the coal regions which appear to have escaped notice, no descriptions of individual faults are given here, as they will be included in the monograph on the coal of Indiana, in preparaton.

Notes on the Geology of Mammoth Cave. By R. E. Call.

A Geological Section Across Southern Indiana from Hanover to Vincennes. By J. F. Newsom.

[Abstract.]

During the field season of 1896 a geological section was run through the center of the row of townships numbered 3 N. from Hanover on the Ohio River to Vincennes on the Wabash.

The profile was run by means of the vertical arc and aneroid barometer. The dips of strata and elevations as shown may be depended upon within the limits of these methods.

The geological formations and the topography crossed by this section are typical of almost the entire southern portion of Indiana.

The lowest rocks to be found in the section are the soft beds of the Cincinnati group along the Ohio River. These beds are about 250 feet thick in the region near Hanover.

Overlying the Cincinnati beds are the hard limestones of the Clinton, Niagara, and Corniferous. It is this combination of limestones overlying the soft Cincinnati beds that causes the bluffs along the Ohio River, and the waterfalls that are so common in that region.