

SECTION V.—SEISMOLOGY.

THE ALABAMA EARTHQUAKE OF OCTOBER 18, 1916.

By RUY HERBERT FINCH, Assistant.

[Dated: Seismological Investigations, Weather Bureau, Jan. 30, 1917.]

An earthquake occurred on October 18, 1916, a little to the northeast of Birmingham, Ala., that has been reported from eight different States: Alabama, Georgia, Indiana, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. Undoubtedly it was felt in Florida also, as Geneva on the Alabama-Florida line reported it with an intensity of II, Rossi-Forel.

The occurrence of this earthquake was unnoticed in many places owing to the high winds and heavy rain incident to a hurricane then passing over the east Gulf States. Several persons, in fact, mistook the earthquake disturbance for wind effects. Thus, the observer at Marshallville, Ga., remarked to his wife, "We are having some wind to-day," to which she replied that there was just one strong gust and that it had died down.

The data used in this note, given in some detail on pages 589-590 in the MONTHLY WEATHER REVIEW for October, 1916, were obtained from some 200 card reports rendered by Weather Bureau cooperative observers, United States postmasters, and others. Thanks are specially due to Mr. W. N. Maddox, of Easonville, Ala., who furnished much valuable information.

The influence of the geologic structure on the propagation of the earthquake waves is shown by the fact that the earthquake was felt 340 miles to the north and to the east, 190 miles to the south, and only 130 miles to the west, where the waves encountered the unconsolidated material of the Mississippi Delta. To the northeast along the continuation of the ridge in which the epicenter is situated, the quake was not felt as far as it was to the north and east. (See fig. 1.) An interesting account of the difference in effects of an earthquake on dry hilly land and moist sandy land was furnished by Hon. R. E. Thompson, of Toomsba, Miss. Mr. Thompson, whose house is located on a damp sandy foundation, felt and could give a good description of the earthquake, while his neighbors whose houses are on higher and drier land did not know that anything unusual had occurred.

Instrumental records of the earthquake were made by the seismographs of the University of Kansas at Lawrence, Kans., Georgetown University, and the Weather Bureau at Washington, D. C.

The highest intensity reported was VII-VIII (Rossi-Forel) at Easonville and Irondale, Ala. The different intensities as reported are shown on the accompanying chart. The isoseismals are, of course, only relatively accurate and are drawn for average values. The inaccuracy of isoseismals based upon a few reports is well illustrated by the fact that Lewisburg, Tenn., reported the quake with an intensity of IV-V, while a small hamlet on a rural free mail delivery route from Lewisburg reported that it was not felt.

The time of the shock as given by a majority of reports was 4:03-4:04 p. m., 90th meridian time. Mr. C. F. von Herrmann, in charge of the Weather Bureau office at Atlanta, Ga., reported two shocks and gave the time

very accurately, reporting the first shock at 4^h 04^m 05^s and the second at 4^h 05^m 25^s p. m. But as Atlanta is about 130 miles from the epicenter it may be that these two shocks were only different phases of the same quake. The average time of the occurrence at the epicenter, as determined from the seismograph records of the University of Kansas, Georgetown University, and the Weather Bureau at Washington by means of the P-O table of Dr. Klotz, is 4^h 03^m 14^s p. m.

As is usual, the main shock of October 18 was followed by several weaker ones. At 10:54 p. m. October 18 a shock was felt over most of the territory bounded by the VII isoseismal. A few people felt shocks at about 9 p. m., October 22, and on the morning of October 28. Birmingham was shaken by a light tremor at 6:15 a. m. November 4, but there is some doubt as to whether this was seismic or due to a mine explosion.

The Geological Survey detailed a trained geologist, Mr. Oliver B. Hopkins, to make a study of the epicenter region, and his interesting report follows.

NOTES RELATING TO THE EARTHQUAKE OF OCTOBER 18, 1916, IN NORTH-CENTRAL ALABAMA.¹

By OLIVER B. HOPKINS, Associate Geologist.

[Dated: U. S. Geological Survey, Washington, D. C., Jan. 8, 1917.]

Observations.

Time.—According to Mr. C. J. Yow, train dispatcher of the Southern Railway at Pell City, Ala., the most intense shock occurred at 4:03 p. m. (90th meridian time), October 18, and smaller, but distinct, shocks at 8:53 p. m. and 9:11 p. m. on October 22. Other shocks are reported by a number of people as having occurred at about 11 p. m. October 18 and about 6 a. m. October 28. The first shock at 4:03 p. m. on October 18 is the only one which was sufficiently severe to be generally felt from Birmingham eastward beyond Pell City.

Duration.—The duration of the first shock has been variously estimated from less than one-half minute to more than a minute. No close estimate of the actual time during which the movement could be felt can be given because few people realized that any disturbance was taking place until it had reached its maximum intensity. An observer near Easonville was certain from his action during the shock that it could be distinctly felt for more than a minute; on the other hand another observer at Irondale stated that it could be felt probably less than one-half minute, since he rushed out of doors as soon as he was conscious of the shaking and when he got outside the shaking had ceased.

The subsequent shocks were less severe and were experienced by few people.

Direction of vibration.—The examination of a number of fallen objects, principally chimneys, near Easonville, Pell City, and Irondale, suggests that the direction of

¹ Published by permission of the Director of the U. S. Geological Survey, as conveyed in his letter of Jan. 8, 1917.

vibration was from east to west. At Easonville a small water keg, resting on an east-west shelf was overturned to the west and did not roll off the shelf. Three-fourths of a mile east of Easonville about 30 bricks from a chimney fell in an easterly direction. Near Pell City a farmer, who was standing on the southwest side of a fence during the shock, clearly felt the fence being heaved toward him (or himself being heaved toward the fence). The examination of 14 chimneys in Irondale which were partially destroyed, showed that 10 of them fell either to the east or west.

On the other hand, half a dozen bricks, which were dislodged from a chimney on the south side of the courthouse at Pell City, fell to the south, and several of the chimneys in Irondale fell as if they had been rocked in no particular direction, the bricks falling in all directions.

Noises.—The noises reported consisted of two kinds—those due to the earthquake itself and those caused by the disturbance of objects. Simultaneously with the shock came a low rumbling noise, which has been likened to the rumble of heavy distant thunder or to the hum of a distant motor. Some likened the noise and shaking to the sudden gust of wind on a still day. This noise was clearly heard by many people from Irondale to Pell City.

The principal noise, which caused the people to be frightened was due to the disturbance of objects, such as the creaking of the houses, the rattling of dishes, and the falling of bricks, etc.

Effect on people.—From the eastern edge of Birmingham to Pell City most of the people within doors at the time of the severe shock were so frightened that they rushed outdoors for fear their houses would fall: on the other hand, probably one-half of those who were out of doors at that time were entirely unconscious of the earthquake. Only one case of personal injury has been heard of, and that was caused by a falling brick. In the central part of Birmingham the effects of the earthquake were much less pronounced, and many people, who were indoors were either barely conscious of the earthquake or not conscious of it at all. Two persons who were asleep in the hotel at Pell City were suddenly awakened by the shock and so badly frightened that they rushed from the building.

The subsequent shocks were so mild that only a few people experienced them, and few persons, if any, were alarmed.

In Selma the first shock was distinctly felt by many, but it was not sufficiently intense to cause alarm. In general, people on the upper floors of buildings felt the shock, whereas those on the ground or on the lower floors were unconscious of it.

Effect on objects.—Judging from the number of chimneys partially destroyed, the shock was more severe in Irondale than in any other part of the region between Easonville and Birmingham. Here 14 chimneys were partially destroyed within an area of two blocks. Six chimneys on a brick store were practically leveled to the roof. Many others were either leveled to the house roofs, or so badly cracked that they had to be rebuilt. Much less damage was done to chimneys in the surrounding area and farther west, toward Birmingham, although many poorly built chimneys were partially destroyed in the eastern edge of town. In Pell City a few bricks were dislocated from one of the chimneys of the courthouse. Near Easonville slight damage was done to a few chimneys and a few objects were upset. Effects of a similar nature near Vincent are reported, but were not verified.

Disturbance of the earth surface.—A fissure and a landslide were reported to have been caused by the earth-

quake near Easonville. An investigation of these and other reported surface effects in that vicinity failed to reveal any evidence of surface dislocation of importance or to yield exact information as to the location of the readjustments which produced the earthquake shock. The fissure reported was relatively insignificant, and may or may not have had any connection with the earthquake. The landslide unquestionably antedated the earthquake by a month or two, and was in itself of little significance. The result of greatest geologic significance, so far as could be learned, was the effect upon the underground water, particularly in Irondale; a number of wells either went dry after the shock or the water in them was lowered.

The fissure referred to was developed in the back yard of J. M. Farley, on the property of L. C. Davis on Kelly Creek, 6 miles north of Vincent. Mr. Farley is positive that he saw the crack at least an hour before the earthquake occurred, although he states that it was larger after the earthquake than it was before. In maximum size the fissure was 12 feet long, 1 inch wide, and 18 inches deep. It extended in an east-west direction. At the time of the writer's visit only indistinct traces of the fissure could be seen. Although the origin of the fissure is obscure, it may be connected with the solution of limestone which underlies that area. This supposition is supported by the presence of limestone sinks near by, and by the presence of a bold spring of strong limewater which issues from the base of the hill.

No other fissures could be found and no reports of any others could be obtained with the exception of a crack in the bottom of a well near Irondale, which is probably due to the earthquake movement.

The landslide, which is referred to above, unquestionably antedated the earthquake by a month or more, according to the unanimous opinion of the people who live in the vicinity. It consisted of a tree, some large rocks, and other debris sliding from a steep bluff into the road after a prolonged rainy season.

The most interesting effect of the earthquake was the drying up of a number of heretofore unfauling wells and the lowering of the water level in others. The elevation of the water in a well in Pell City was lowered 2 feet by the earthquake. This lowering of the water level was definitely determined since the rope on the windlass was too short to reach the water after the earthquake. A small "dry weather" branch north of Dykes mill is reported to have begun running immediately after the earthquake, whereas it had been dry for months before. This report could not be verified. In Irondale² five wells within a single block went dry immediately after the earthquake, and in many of the surrounding ones the water level was materially lowered. The wells that went dry in Irondale after the earthquake are on the southern edge of the town and on slightly higher ground than the rest of the town, whereas the chimneys most affected are in the central and northern part of town on low ground.

Relation of earthquake effects near Irondale to Red Gap fault.

A careful study of the Red Gap fault, which extends from near Gate City to beyond Irondale, failed to reveal any direct evidence of recent movement. If the readjustments which caused the earthquake produced any surface cracks or showed in any way in the surface material, these results were very slight and all traces

² Population was 572 in 1910.

of them had been obliterated at the time of the writer's visit.

On the other hand, the effect on the underground water conditions proves that there was movement in the rocks of this area attending the earthquake, and strongly suggests that there was movement along this old fault plane. As shown in the Birmingham geologic folio, published by the United States Geological Survey, this fault passes approximately through the center of Irondale. Practically all the wells along the eastern end of the fault, as shown on that map, either went dry or the water level in them was materially lowered. Most of the wells which went dry are located one block south of the fault line on a slight elevation, as compared with the others in town. Within a block five wells, ranging from 35 to 40 feet deep, went dry, whereas the sixth in the row which was only 14 feet deep did not. Two other wells, probably along the eastern extension of this fault or near it went dry. One is a few hundred yards east of the center SE. $\frac{1}{4}$ sec. 29, T. 17 S., R. 1 W., 4 miles east of Irondale; it was 28 feet deep and had 7 feet of water in it before the earthquake. The second well is 200 yards east of center of W. line of SW. $\frac{1}{4}$ sec. 19, T. 17

S., R. 1 W.; it was 47 $\frac{1}{2}$ feet deep and had produced water for two years before the earthquake. After the well went dry it was found to have a crack 1 $\frac{1}{2}$ inches wide crossing its bottom in the direction N. 33° E. This crack, which did not show at the surface or in the upper part of the well, has been followed downward in deepening the well about 30 feet. The well is still dry in spite of its increased depth and the crack still shows in the bottom of the well.

Conclusions.—The direction of movement, the intensity of the shock, and the effect upon the underground water near Irondale, suggest that the locus of the disturbance which produced the earthquake was along the Red Gap fault, which runs through Irondale; and that the movement along this fault was horizontal rather than vertical. Had the movement along this fault been vertical the direction of the resultant vibrations would have been at right angles to the line of fault, or approximately north and south, instead of east and west as it was found to be. The occurrence of the fissure in the well described above may be the result of this horizontal or torsional movement.

SEISMOLOGICAL REPORTS FOR DECEMBER, 1916.

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[Dated: Weather Bureau, Washington, D. C., Dec. 1, 1916.]

TABLE 1.—Noninstrumental earthquake reports, December, 1916.

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
ARIZONA.										
1916.	<i>H. m.</i>						<i>M. s.</i>			
Dec. 12	12 45	Fort Apache.....	33 47	109 55	5	1	0 3	Rumbling.....	Awakened people.....	J. C. F. Tillson, jr. G. J. Henry.
	12 45	Henry's Camp.....	33 41	109 48	5	1	7	None.....	.....	Thorwald Larson.
	12 45	Holbrook.....	34 54	110 08	5	1	15	None.....	.....	T. H. Owens.
	12 45	Lakeside.....	34 06	109 59	4-5	1	60	None.....	Dishes rattled.....	E. Thomas, jr.
	12 45	Pinedale.....	34 19	110 15	5	2	6	None.....	.....	Mrs. Cella Henning.
	12 45	Pinto.....	35 05	109 38	5	1	15	Rumbling.....	Doors slammed.....	F. R. Wigely.
	12 45	Shumway.....	34 26	110 04	5	1	3	Rumbling.....	.....	W. J. Flake.
	12 45	Snowflake.....	34 33	110 04	4	1	.....	None.....	Awakened people.....	St. Michaels School.
	12 45	St. Michaels.....	35 38	109 05	5	1	.....	Rumbling.....	Some plaster cracked.....	T. C. Snow.
	12 45	Thatcher.....	32 50	109 47	3	1	20	None.....	.....
CALIFORNIA.										
1	22 50	San Luis Obispo.....	35 18	120 39	7	1	0 8	Rumbling.....	Plaster fell.....	U. S. Weather Bureau. Walter White.
	22 50	Santa Maria.....	34 58	120 28	3	1	.....	None.....	.....
7	18 55	Calxico.....	32 40	115 28	5	1	.....	Rumbling.....	.....	F. R. Spencer.
7	20 30	Bishop.....	37 21	118 22	3	2	8	None.....	.....	E. L. Herzinger.
7	20 45	Calxico.....	32 40	115 28	5	1	.....	Rumbling.....	.....	F. R. Spencer.
18	19 50	Calxico.....	32 40	115 28	2	1	.....	Rumbling.....	.....	F. R. Spencer.
KENTUCKY.										
19	5 42	Hickman.....	36 35	89 12	5-6	2	.....	Rumbling.....	Bricks shaken from chimneys.....	J. C. Sexton.