THE CORNWALL-MASSENA EARTHQUAKE SEPTEMBER 5, 1944

By Ernest A. Hodgson

(With Plates II, III, IV, V)

SHORTLY before 12: 40, E.W.T., in the early morning of Tuesday September 5, 1944, a moderately severe earthquake disturbed many persons, some asleep, others up and about, over a widespread area in eastern Canada and New England. The papers next morning carried news items showing that it had been felt as far south as New York city, west to Windsor and Detroit, eastward to at least Quebec city, and up into the mining districts of northern Ontario and Quebec. Later reports indicated that it was felt at Rupert House on James Bay. The damage was confined to a comparatively small region in the vicinity of Cornwall, Ont., and Massena, N.Y., which lies about ten miles south-west of Cornwall. It recorded on seismographs at Pasadena, California.

The Ottawa seismographs recorded the tremors, but the disturbance was so great that it was difficult to determine the epicentral distance accurately from the first, main shock. However, there were quite a number of aftershocks felt in the vicinity of Cornwall and Massena, of which three were registered at Ottawa. The second of these, at about 5 a.m., E.W.T., September 5, was very well recorded. Determined from this record, the epicentral distance was found to be 59 miles. Using this value for distance, together with the time of the first onset of the initial disturbance, the computed focal time for the main earthquake was 4:38:44, U.T., September 5 (12:38:44, a.m. E.W.T., Sept. 5).

The seismogram from Shawinigan Falls was received at Ottawa within a couple of days. The main shock was here sufficiently attenuated by distance to permit a direct reading. Using the Shawinigan record alone, the focal time was independently determined as 12:38:42, E.W.T., and the distance from Shawinigan Falls to the epicentre was found to be 140 miles. The distance circles about Ottawa and about Shawinigan Falls intersect at a point a couple of miles south and a little east of the southern end of the international bridge at Cornwall.

PLATE II

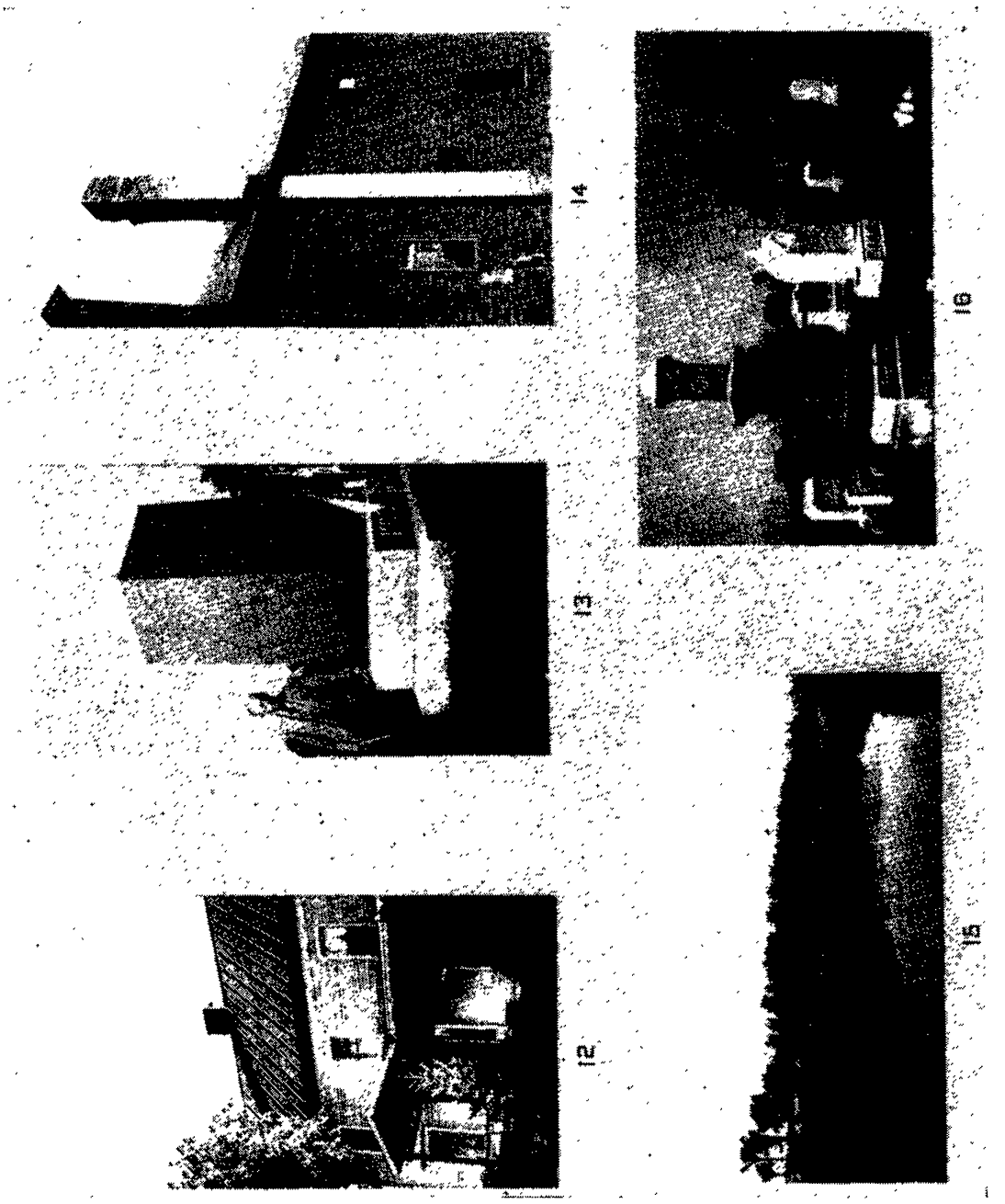
The Cornwall-Massena Earthquake, September 5, 1944.

(Photograph by Lafayette, Ltd., supplied by courtesy of Harvard Observatory.)

PLATE III

The Cornwall-Massena Earthquake, September 5, 1944.

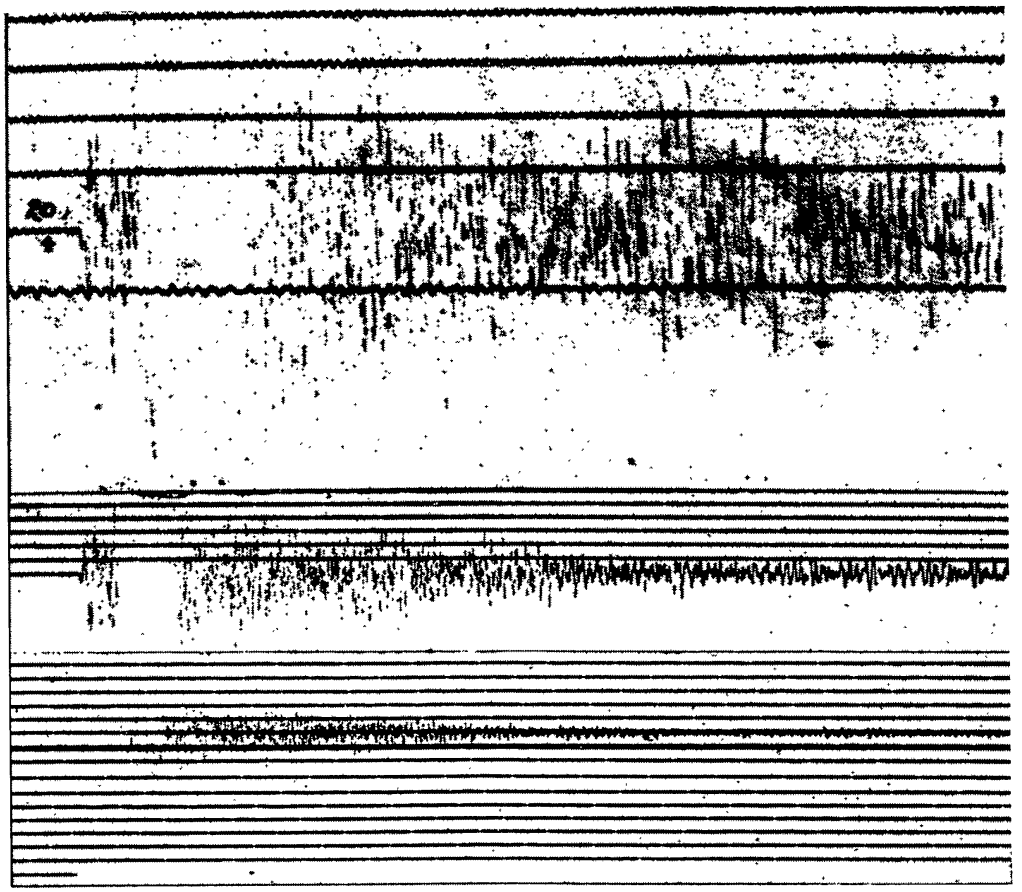
(Photograph by Lafayette, Ltd., supplied by courtesy of Harvard Observatory.)



The Cornwall-Massena Earthquake, September 5, 1944.

(Photograph by Lafayette, Ltd., supplied by courtesy of Harvard Observatory.)

PLATE V



SEISMOGRAMS OF THREE MAJOR CANADIAN EARTHQUAKES

The illustration is a composite photographic reproduction of the seismograms of the earthquakes of 1925, 1935 and 1944, respectively having their epicentres in the lower St. Lawrence valley, at Timiskaming, Que., and at Cornwall. Each was made on the same Milne-Shaw seismograph at the Dominion Observatory, Ottawa. The 1925 quake was registered at a paper speed of 15 mm/min., the other two at 30 mm/min. In order that the relative duration of the preliminary phase might be on the same time scale on each record in the composite lay-out, the two lower seismograms were each reduced to half-scale. Hence, to compare recorded amplitudes, these two sections must each be multiplied by the factor 2. The epicentral distances were, respectively, 300 mi., 180 mi. and 60 mi. The ratio of focal energies may be determined by multiplying the recorded amplitudes by the squares of the respective epicentral distances. The ratio of focal energy release is thus, approximately, 26:12:1. That is to say, the St. Lawrence earthquake released about 26 times as much energy at the focus as did the Cornwall shock; and that at Timiskaming only about 12 times that much. Yet, the ratio of estimated damage was—5:1:200. This is largely due to the fact that the Cornwall epicentre was occupied by so many buildings, erected on a deep sandy terrain.

It was decided that a field survey should be made from the Dominion Observatory. As the weather was fine and the epicentre evidently lay in a region of good roads, it was possible to use an automobile. Arrangements were made to have Mr. Hector Gauthier of the Observatory staff drive his own car and accompany the writer on the field trip. It was a most satisfactory arrangement —a great improvement over other earthquake field trips, made over rough country in bad weather and alone. It is surprising how much more can be accomplished with one to dictate observations and another to keep the notes. The car was not only a great convenience and comfort in getting from place to place, but it saved much time and permitted a greater coverage. The odometer readings conveniently located the place where each note was recorded.

Another fortunate circumstance was of very great assistance at the beginning of the investigation, when it was most needed. Just before leaving Ottawa, a visit was received at the Observatory from Mr. I. W. Clarke of the Montreal office of the Associated Factory Mutuals Insurance Company. He was returning from an inspection trip over the Cornwall-Massena area, carried out in company with Mr. H. A. Sweet from the Boston Head Office of the same organization. Mr. Clarke furnished some data of immediate value and arranged to have Mr. Sweet wait over at Cornwall in order to spend a day with the Ottawa men. From him much was learned about the distribution of damage in Cornwall and in Massena. He had not only visited the factories in which his company is interested but had interviewed civic engineers and others, inspected the general damage in various parts of Cornwall, collected photographs and news clippings and experienced some of the aftershocks.

One of the most helpful suggestions made by Mr. Sweet was that steps be taken to secure back copies of certain newspapers: the *Cornwall Standard Freeholder* (which had just issued a special extra containing exclusively their own earthquake news to Sept. 8), the *Massena Observer*, the *Watertown Times*, and the *Syracuse Post Standard*. The last named had published a questionnaire on the earthquake on behalf of Prof. G. Woodruff, of the Department of Geology, Colgate University, Hamilton, N.Y. This led to corre-

spondence with Prof. Woodruff, who has promised to place the data he collects at the disposal of the Observatory in the preparation of a later report on this earthquake. Mr. Sweet has furnished a copy of his inspection report, also to be consulted in preparing that publication.

Throughout the course of many contacts with newspaper men at the time of an earthquake, our experience has been that they are inclined to take all one can give them, after which they rewrite it into what is often a ridiculously exaggerated or inaccurate "story" and that they then invariably forget their promise to send a copy of that story as printed. It is particularly pleasant to report that, quite contrary to past experience and to then expectation, every newspaper consulted in this investigation not only placed all available information freely at our disposal and gave excellent and accurate reports of interviews, but in no case did they neglect to send a copy of what they had written. Some are continuing their collaboration by making studies of their back files. This is particularly true in the case of Editor Harold B. Johnson, of the *Watertown Daily Times*.

The trip of inspection was begun in the late afternoon of Saturday, September 9. Surveying was carried out en route from Morrisburg to Cornwall, where Mr. Sweet was found waiting. The group was at dinner in the Cornwallis Hotal at 7:25 that evening, when a severe aftershock was experienced, which brought all diners to their feet in a hurry. Fortunately, the tremors lasted only a few seconds; there was no time for panic. The disturbance began as a faint rumble, quickly becoming stronger and followed by an explosive *bang*, which felt as though the boiler had exploded in the basement, after which it terminated with a few rumbling sounds. It was decidedly the most severe shock which the writer has ever felt in his limited personal experience. It was registered at Ottawa, where the seismographs showed it to be of about the same intensity as the one at 5 a.m. on September 5. These two have been, so far, the most severe of the many aftershocks, which were at first experienced every few hours and than at increasingly longer intervals, continuing up to the date of writing this account.

In an interview with Mayor Horowitz, the writer discussed the damage in Cornwall. There are 3081 buildings in that municipality

proper. An estimate of an average of $200 damage to each of these was made, after a general survey, by a group of contractors and engineers. In addition, there was considerable damage to public buildings, factories, etc. The total rough estimates ran from $750,000 to $1,000,000. At the time of the interview, few of the more precise determinations of damage to particular buildings were yet available. About 2,000 chimneys alone were so badly damaged in Cornwall as to require repairs. Considerable loss was suffered by householders and storekeepers from the destruction of glassware, etc., and the cracking of brick and plaster walls. It is a nice question just what is meant by total earthquake damage.

If every house, public building and factory is to be put back into the same condition as before the earthquake, and if all rooms are to be re-decorated, all broken articles replaced, etc., then such an estimate of the damage rests at the maximum value. If the money which will actually be expended in recovering from the disaster is to be taken as the measure, the estimate will be a minimum. The difference between these two figures is evidently large. Cracked walls of churches, factories, etc., may be strengthened with bolts and plastered over. Some will be replaced. Much of the broken glassware in private houses will be written off. Many square yards of cracked plaster will remain cracked. After having seen samples of the damage in many parts of Cornwall, it would seem that the $1,000,000 estimate is close to the maximum referred to above.

But, whatever the estimate adopted, the damage was plenty; whether one considers it from the point of view of the private citizen forced to get his chimney repaired in a hurry, or that of the factory executive faced with the need for prompt attention to a 200-foot smokestack, or that of the school trustees required, literally at a moment's notice, to put the schools into condition to meet the insistent demands (?) of the school population just getting back after the holiday season.

Mayor Horowitz enquired as to the likelihood of further serious shocks. It was pleasant to be able to assure him, on the basis of all previous experience, personal and derived from reports on many earthquakes, that, while it was practically certain that there would be aftershocks varying in intensity but gradually becoming less

and occurring at longer intervals, it was not at all likely that any of the aftershocks would be more severe than the two large ones already experienced. This report was published in the *Cornwall Standard Freeholder* (a very accurate report of the statements made) and was said to have been of considerable comfort to many.

A warning was added that chimneys should be carefully checked, both above the walls and within them, and repaired at once if any cracks were found. This was a difficult prescription to have filled, as there was a marked scarcity of both bricks and bricklayers, due to wartime regulations governing both men and materials. However, the Mayor and his assistants did manage to secure the authority, the supplies and the men to meet the need, and the weather was most accommodating.

The damage in Massena was also estimated at $1,000,000. Here, too, there were said to be 2,000 chimneys requiring repairs. The chimney damage seemed about as great there as in Cornwall, but the sum total of all reports received during the investigation left one with the feeling that the overall damage in Massena was, perhaps, somewhat less than that in Cornwall. This would appear to have been due to differences in foundation subsoil, rather than to any difference in the severity of the tremors; for there was plenty of evidence that Massena is probably closer to the epicentre than is Cornwall. Some wells in the vicinity (and also across the river on the north shore) were said to have dried up, others began to flow, and a crack in deep alluvium north of Massena Centre oozed water and sand. Such phenomena are generally found in epicentral regions.

The investigation in Massena owes much to the collaboration of Mr. Leonard Prince of the Massena Observer, who not only furnished data on local conditions after the earthquake, but made it possible to meet executives of some of the local industries. In this way, within a few hours, a surprising amount of information was obtained and further data were promised. This material can receive only general attention here, but will be dealt with fully in a later report, as will similar data obtained from executives of companies in Cornwall, resulting from contacts made through the Kiwanis Club there. Such data cannot properly be published without a release from the organizations concerned.

One of the field evidences sought when on a trip of this kind is of a negative nature: old chimneys which were not damaged, old barns obviously rickety which did not collapse, etc. It was surprising to find that the negative evidence began to show up quite markedly only five miles or so east of Cornwall on the Canadian side, and within about the same distance eastward from the international bridge on the south side of the river. Almost none was found at Hogansburg and none at all in Ft. Covington. But the damage tapered off at a much slower rate going west. It was more than fifteen miles west of the Cornwall-Massena region before marked negative evidence was found, at Waddington on the south shore and Morrisburg on the north.

The damage was reported by Clarke and Sweet to be spotty and, as is always the case, this spotty damage marks the parts having deep or sandy subsoil. This fact is particularly noticeable in the city of Cornwall, where information as to subsoil conditions was furnished to Mr. Sweet by Col. W. H. Magwood, the City Engineer. Those parts of Cornwall which suffered the least damage were, definitely, the sections which are not underlain by a sandy deposit sometimes spoken of locally as "quicksand", although, technically, this is said to be a misnomer. More will appear presently in this connection when speaking of the damage in the Cornwall cemeteries.

In any field study in an epicentral region, the investigator makes it a point to visit the cemeteries. If it were known beforehand that an earthquake would occur in a given locality, much information could be obtained by setting up regular, symmetrical columns of various dimensions on solid, level bases and, after the earthquake, making a study of its effects on these columns. Where could one find a more effectively based, carefully placed set of "seismoscopes" of various dimensions than in a modern, well-kept cemetery?

Accordingly, care was taken to visit every cemetery which could be found to have suffered any damage. In all, careful surveys were made of fourteen in the epicentral region. As sufficient photographic film for only eighteen exposures could be obtained during the time of the field trip, most of the pictures were taken in the cemeteries and, consequently, nearly all the illus-

trations in this article show the earthquake effects on gravestones.

The first cemetery visited, and the one farthest from the epicentre to show marked damage, is at Farrans Point, Ont., on the St. Lawrence, twelve or thirteen miles (in an air line) west of Cornwall. The six illustrations of Plate II show effects in this cemetery. It is to be noted that the stones are, in general, modern and well-placed, and that the grounds are fairly level and well tended. It will be noticed that, in nearly every case, they have been turned on their bases, and that all rotations are in a contra-clockwise sense. Every stone in this cemetery which was rotated (and there were at least twenty) was so directed. The stone in Fig. 2 was shifted bodily west at the grass line, leaving a crack about two inches wide. Note that the urn (in Fig. 1) was found lying close to the plinth. Reference will be again made to this fact. The marks in the soft soil showed that it had fallen where it lay at the time the picture was taken.

In Cornwall, there are three cemeteries of the larger type: the "French" cemetery in the north-east corner of the town, St. Columban's in the north-west corner, and Woodlawn, half a mile or so directly south from St. Columban's. According to Col. Magwood, as reported by Mr. Sweet, the north-east corner of Cornwall was once an island in a much wider St. Lawrence river. Certain it is that the layer of "quicksand" is not found there. Chimney damage in this district was very much less than in any other part of Cornwall. The stones in the "French" cemetery, located in this part of town, were in good order, with three minor exceptions. The caretaker stated that no repairs had been made—there simply had not been any damage.

Less than two miles directly west of this cemetery is St. Columban's. Here there is a sandy subsoil. Hardly a stone in the large burying ground was left undamaged. Two of these are shown in Figs. 7 and 8. Another, shown in Fig. 11, is quite large, as is evident in comparison with Messrs. Gauthier and Sweet standing beside it. It was not leaning, as might be suspected. The camera was not held level. Figs. 10 and 11 show the vault at St. Columban's. It is of cement blocks and will have to be re-built. Most cement block structures, especially chimneys and garages, in the epicentral region were generally damaged as was this vault.

In Fig. 9 is shown a remarkable case of contra-clockwise rotation in Woodlawn cemetery. The granite ball is highly polished and is about two feet in diameter. Scratches on its surface show that the ball was rotated contra-clockwise by the amount by which the strip of paper extends to the right of the supporting claw. Each of the four claws gave the same measure of rotation indication.

All the stones which rotated in Farrans Point cemetery turned contra-clockwise. About 70 per cent of all rotated stones in cemeteries on the north shore rotated in this sense also. Exceptions to the rule were mostly in a closely related group in each case, usually close to trees.

On the south shore an even higher percentage of rotated monuments were turned in a clockwise sense. Examples are shown in Figs. 13 and 16. These pictures were taken in a cemetery at Massena Center, about four miles east of Massena. Nearly all the stones in this cemetery, and a very large percentage of those in a large cemetery in Massena, were damaged, most of them by being rotated. And, in most cases, the rotation sense was clockwise. Exceptions to this rule, in the Massena cemetery, were again almost entirely confined to isolated groups close to trees.

It is also to be noted that the urn, which has fallen from the smaller monument in Fig. 16, did not part at a joint. The neck of the ornament was broken. It was thrown clear, a good three feet from the base. Marks in the soil, and absence of scratches on the monument, testify to the fact that it did not roll to the point shown. Compare this fall with that in the Farrans Point cemetery, as shown in Fig. 1. In general, the direction of fall of ornaments in cemeteries and of other objects in different locations was so varied that little significance could be given this type of evidence. Just what significance attaches to the consistent partition of rotation direction north and south of the river the writer is not prepared to say.

One of the most convincing pieces of evidence, supporting the deduction that one is near the epicentre, is the prevalence of chimneys damaged as shown in Figs. 12 and 14. The earthquake blows are here delivered with such force and in so nearly vertical a direction that the bricks of the chimney have been jarred apart but have not fallen from the chimney. There were some "up-

bumped" chimneys in Cornwall; one of the best examples in Massena is shown in Fig. 14; but in Massena Center nearly every chimney in the village was so damaged, as was the one shown in Fig. 12. This fact, taken in conjunction with the great disturbance of the monuments in the cemetery there, indicate that the epicentre was very close to Massena Center. This is about five miles west of the intersection of the distance circles about Ottawa and Shawinigan Falls. The point of intersection is close to the scene shown in Fig. 15. Had there been a town at this particular spot, it might have been damaged even more than was Massena Center.

So, tentatively, the epicentre is thought to be somewhere in the vicinity of Massena Center, and the focal depth is probably fairly deep—20 miles or so, since the tremors of what was really not a major earthquake were felt to such great distances. Certainly the shock was less than that of the Timiskaming earthquake of November 1, 1935, and very much less than that which had its epicentre on the south shore of the St. Lawrence, about 40 miles below Quebec city, on February 28, 1925.

A complete study of the Cornwall-Massena earthquake is being undertaken by the Dominion Observatory. Seismograms from all seismograph stations in North America have been requested. A widely-distributed questionnaire has been sent out in Canada, in addition to those in the United States. Many co-operating agencies and organizations are furnishing data. When all have been studied, a report will be compiled which may change by small amounts the present, tentative deduction that the Cornwall-Massena earthquake occurred at the focal time 4:38:44, U.T., September 5, 1944, with the epicentre near Massena Center, N.Y., and the focal depth of the order of 20 miles.

Dominion Observatory,
Ottawa, Canada.
December 4, 1944.