
PHILOSOPHICAL
TRANSACTIONS.

- I. *An Account of the Earthquake felt in New England, and the neighbouring Parts of America, on the 18th of November 1755. In a Letter to Tho. Birch, D.D. Secret. R. S. by Mr. Professor Winthrop, of Cambridge in New England.*

Reverend Sir,

Read Jan. 13, 1757. **I** Beg leave to lay before you the best account I am able to give of the great earthquake, which shook New England, and the neighbouring parts of America, on Tuesday the 18th day of November 1755, about a quarter after four in the morning. I deferred writing till this time, in order to obtain the most distinct information of the several particulars relating to it, both here and in the other places where it was felt; and especially the extent of it.

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The night, in which this earthquake happened, was perfectly calm and serene. In the evening there was a fog over the marshes bordering on the river Charles, which runs through this town: but this I found intirely dissipated at the time of the earthquake, the air being then quite clear, and the moon, which wanted but 36^h of the full, shining very bright. The earthquake began with a roaring noise in the N.W. like thunder at a distance; and this grew fiercer, as the earthquake drew nearer; which was almost a minute in coming to this place, as near as I can collect from one of my neighbours, who was then on the road in this town. He tells me, that, as soon as he heard the noise, he stopt, knowing, that it was an earthquake, and waiting for it; and he reckoned he had stood still about 2', when the noise seemed to overtake him, and the earth began to tremble under him: but, as I doubted, whether it were so long, I counted several numbers to him as slowly as a clock beats seconds; and then he said, he believed he could have counted half an hundred, at that rate, before the noise and shake came up to him. By his account, as well as that of others, the first motion of the earth was what may be called a pulse, or rather an undulation; and resembled (to use his own comparison) that of a long rolling, swelling sea; and the swell was so great, that he was obliged to run and catch hold of something, to prevent being thrown down. The tops of two trees close by him, one of which is 25, the other 30 feet high, he thinks waved at least ten feet (and I depend on his judgment in this particular, because he judged right of the height of the trees, as I found by actual mensura-

menfuration); and there were two of thefe great wavings, fucceeded by one, which was fmaller. This fort of motion, after having continued, as has been conjectured, about a minute, abated a little; fo that I, who was juft then waked, and, I fuppofe, moft others, imagined, that the height of the fhock was paff. But infantly, without a moment's intermiffion, the fhock came on with redoubled noife and violence; though the fpecies of it was altered to a tremor, or quick horizontal vibratory motion, with fudden jerks and wrenches. The bed, on which I lay, was now toffed from fide to fide; the whole houfe was prodigioufly agitated; the windows rattled, the beams cracked, as if all would prefently be fhaken to pieces. When this had continued about 2', it began to abate, and gradually kept decreasing, as if it would be foon over: however, before it had quite ceafed, there was a little revival of the trembling and noife, though no-ways comparable to what had been before: but this prefently decreased, till all, by degrees, became ftill and quiet. Thus ended this great fhock. It was followed by another about an hour and a quarter after, viz. at 5^h 29'. This, though comparatively fmaller, was very generally perceived, both as to its noife and trembling, by thofe who were awake. On the Saturday evening following, viz. the 22d of November, at 27' after eight, there was a third, more confiderable than the fecond, but not to be compared with the firft. And on Friday the 19th of December in the evening, exactly at ten o'clock, there was a fourth fhock, much fmaller than either of the former, though, like them, preceded by the peculiar noife of an earthquake.

The whole lasted but a few seconds ; but the jarring was great enough to cause the window-shutters and door of the room, in which I then was, to clatter. The sky was perfectly clear, and there was a very gentle and scarcely-perceptible gale at S.W. These four are the only shocks, that I have been sensible of from the 18th of November last to this date ; tho' more are said to have been felt in other parts of the country to the northward of us.

As to the duration of the great shock, people have differed widely, viz. from 1' to 6 or 7. Our printed accounts have generally fixed it to about 2', or 3' at the most ; but as these were only the uncertain guesses of persons, who had no rule to guess by, no dependence can be had on them. I am well satisfied, that with us it continued 4', or rather 4' 1-half, taking in the whole of the time, from the first agitation of the earth till it was become perfectly quiet ; tho' the violence of the shock did not last above half so long. This I am assured of, partly from the observations of some gentlemen, who were up, and looked on their watches, when it began and ended ; one of whom tells me it was 4', and another, that it was near 5 ; and partly from my own observations, which were as follow. The preceding noon I had adjusted both my clock and watch to the apparent time, by a meridian line ; and the following noon I found, that the watch had kept time exactly. Being awaked by the earthquake, I lay till the violence of it seemed to be over for the second time, the first abatement happening just after I waked. Till then I forbore to rise, because the agitation was so vehement, that I concluded it would be difficult, if not impracticable,

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to go from the bed to the chimney, without being thrown down; and therefore thought it best not to attempt it. The space of time, in which I lay awake, I cannot think to be much, if any thing, less than 2'. This was the conjecture I formed at that time; though, it being but conjecture, I would not lay very great stress upon it, were it not supported by concurring observations. On the second abatement I rose, and lighting a candle, looked on my watch, and found it to be 15' after four. The shock then was not quite over, but the windows continued rattling for about a minute longer, as near as I can remember; for the shock went off very gradually. As soon as I had looked on the watch, I went directly to the clock, which was in another chamber, that I might see whether that agreed with the watch, and found that it was stopt at 4^h 11' 35". Its stopping, however, was not immediately owing to the violence of the shock, though several clocks, and watches too, at Boston, are said to have been stopped by it, but to the following accident: Having some time before used a pretty long glass tube, in a particular experiment, I had shut it up in the clock-case for security; and this tube, being overthrown by the earthquake, lodged against the pendulum, and stopt its motion. By this accident, the beginning of the earthquake, I conceive, is determined with all the exactness, that can be desired; for, so far as I can learn, the first shake was violent enough to overset so tall, slender a body, and standing in a position so near a perpendicular, as that tube; and it was impossible for the pendulum to make one oscillation, after the tube had struck against it. But
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I am not able to fix the end, nor consequently the duration, with the same exactness: however, from the time, when the clock stopt, to my looking on the watch, it was about 3' 1-half; and the jarring was not quite over till about a minute after this: so that I think I speak within bounds, if I say, that this shock with us lasted at least 4'. In other places, its duration might possibly be different. I was careful to note the time, when we had it, as exactly as I could, in hopes, that, by comparing it with the like accounts from distant places, we might be able to judge, with a good degree of exactness, of the course of this earthquake, the place of its origin, and the velocity of its progress. But all the accounts of the time, which I have yet seen, are so very lax, that no just conclusions can be drawn from them, with respect to either of these points. What I have been able to collect with relation to them, I shall set down presently.

Those, who suppose the duration much shorter, as 1' 1-half, or 2', urge, that a minute is a longer space of time than most people are aware of; which is very true: but it should also be considered, that if we judge of the length of any space of time by the number of ideas, which pass through our minds in that time; a very great fright,---a fright so great, as to take intire possession of the mind for a time, and shut out every idea except that of the present danger, will make us judge the time to be much shorter than it really is. And this, I make no doubt, was the case with many; the surprize, into which they were thrown, being such, as to keep out every idea, except that, which happened to strike their minds with the
greatest

greatest force at the beginning. Thus, several perceived no noise distinct from that, which was occasioned by the crackling of their houses, and the disturbance of the moveables in them; while others, who were waked by the noise, and ran from one room to another, have told me, that they felt nothing at all of the shake. For this reason, the conjectures, which persons in these circumstances made, as to the duration of the shock, ought not to be put into the balance with the actual observations made by watches.

The course of this earthquake seems to have been nearly from N. W. to S. E. My neighbour before-mentioned, who was then abroad, and informed me, that the noise began about the N. W. told me at the same time, that it passed off towards the S. E. and that he heard the noise in that quarter gradually abating, as it became more distant, for about the same space of time after the shock was over here, as he heard it in the N. W. before the shock began here. Other accounts, which I have since met with, agree with this. Those, who were in such clear open places, could make the best judgment in this matter; for such, as were within doors, or surrounded with buildings, might easily be misled by the various reflections of the sound. I am induced to give the greater credit to this information by what I observed myself: for a key, which was thrown from off a shelf in my house, was found at a place on the floor, which bore very near N. W. of the place, from which it fell; though the situation of it before its fall was such, that it might have been thrown in any direction, except towards the S. E.

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An account, which we have lately received from the West-Indies, agrees very well with the supposition, that our earthquake proceeded south-eastward. The account is, that 'on the 18th of November, about two o'clock in the afternoon, the sea withdrew from the harbour of St. Martin's, leaving the vessels dry, and fish on the banks, where there used to be three or four fathom water; and continued out a considerable time; so that the people retired to the high land, fearing the consequence of its return; and when it came in, it arose six feet higher than usual, so as to overflow the low lands. There was no shock felt at the above time.'

As this extraordinary motion of the sea happened about 9^h after our great shock, it seems very likely to have been occasioned by the same convulsion of the earth. Now if this earthquake went off south-eastward into the Atlantic, it must have passed considerably to the eastward of St. Martin's; and, in fact, it did not reach that island, there being no shock felt there. The motion of the sea then was owing to a great agitation raised at a considerable distance in some part or other of the ocean, where the earthquake passed, and from thence propagated to that island. Nor is the length of time greater than what seems to be necessary for this effect. The earthquake itself, at the rate it moved with us, would be some hours in going from hence to the distance of St. Martin's: for sound would be about $2\frac{1}{4}$ ^h in moving to such a distance; and the progress of the earthquake was slower than that of sound, as appears from hence, that the roar of this earthquake arrived here near a minute before the shake. The rest of the

the 9^h might well be spent in conveying the motion excited in the water, from the place where it was excited, to St. Martin's; for the waves raised thereby could not move with near the velocity of sound.

It is worthy of remark, that, of the five great earthquakes, which this country has felt since its settlement by the English, two have gone nearly in the same track as this last did. The first, which was on June 2. 1638, 'came from the northward, and passed 'southward.' By the description given of it, it was very much like our late earthquake, only perhaps not quite so violent. 'The noise and shakes of the 'earthquake, October 29. 1727, seemed,' it is said, 'to come from the north-westward, and to go 'off south-easterly; and so the houses seemed to 'reel.' As to the great earthquakes of 1658 and 1662, we have no account of the courses, which they went in. But, from the other three, it may be reasonably conjectured, that the source of our earthquakes, or the place in which they originate, is in some part of Canada, or perhaps beyond it.

The extent of this earthquake seems to have been greater than that of any of our former earthquakes. This province of the Massachusetts-bay, or rather the province of New Hampshire, about the latitude of 43° north on the sea-coast, seems to have been the center of it, or the place of its greatest violence; and the shake to have been less considerable each way from hence towards the S. W. and N. E. By the accounts we have from the S. W. the shock was less at New York than it was with us; and still less at Philadelphia, which is farther towards the S. W. By the best information I can procure, the

limit toward the S. W. was Chesapeake-bay in Maryland, the shock having been felt on the eastern side of that bay, and not on the western. For the other limit toward the N. E. we are informed, that the earthquake was felt at Annapolis Royal in Nova Scotia, though in a much less degree than with us. It shook off a few bricks from the tops of some chimnies, but was not perceived by vessels on the water. And a letter from Halifax says, ' The earthquake, which happened in the W. extended itself to this place, ' tho' scarcely perceivable here.' But it was not at all felt by our army, which lay encamped at Seganecto, about 100 miles N. from Halifax. Thus Halifax seems to have been very near the N. E. limit. I am not able to ascertain its eastern and western limits ; but it extended to all our back inland settlements ; and was perceived, though in a very small degree, by our army at Lake George, distant from hence about 130 miles N. W. by W. But it was not felt at all at the British fort of Oswego, situate on the south-eastern shore of Lake Ontario, and distant from hence about 250 miles W. by N. So great was the shock in the Atlantic, 70 leagues to the E. of Cape Anne, that the people on board a vessel there were suddenly surpris'd, just at the time of our earthquake, supposing they had run a-ground ; till, on throwing over the lead, they found they had more than 50 fathom water. The extent of the earthquake E. and W. from Halifax to Lake George was about 550 miles ; and its extent along the sea-coast, from N. E. to S. W. at least 800 miles. But if the agitation of the water at St. Martin's was occasioned by our earthquake continued into the Atlantic, as was conjectured above,

above, its extent, in a direction toward the S. S. E. must have been at least 1900 miles.

I shall now proceed to mention the principal effects of this earthquake, for which I can find sufficient vouchers; for many strange things have been related, which, upon examination, appear to be without foundation. Besides the throwing down of glass, pewter, and other moveables in the houses, many chimnies were levelled with the roofs of the houses, and many more shattered, and thrown down in part. Some were broken off several feet below the top, and, by the suddenness and violence of the jerks, canted horizontally an inch or two over, so as to stand very dangerously. Some others were twisted, or turned round in part. The roofs of some houses were quite broken in by the fall of chimnies; and the gable ends of some brick buildings thrown down, and many more cracked. Throughout the whole country, the stone fences were more or less thrown down. The vane upon the public market-house in Boston was thrown down; the wooden spindle, which supported it, about five inches in diameter, and which had stood the most violent gusts of wind, being snapt off. A new vane, upon one of the churches in Boston, was bent at its spindle two or three points of the compass; and another at Springfield, distant about 80 miles westerly from Boston, was bent to a right angle. A distillers cistern, made of plank, almost new, and very strong put together, was burst to pieces by the agitation of the liquor in it; which was thrown out with such force, as to break down one whole side of the shed, that defended the cistern from the weather; as also to

stave off a board or two from a fence at the distance of eight or ten feet from it. In some parts of the country, particularly at Pembroke and Scituate, about 25 miles S. E. from hence, there were several chasms or openings made in the earth, from some of which water has issued, and many cart-loads of a fine whitish sort of sand. These are the principal effects of this earthquake on the land, some of which argue a very quick and violent motion of the earth. Tho' the degree of violence was doubtless different in different places, yet, that I might make some estimate of it with us, I measured the greatest distance on the ground, to which any of the bricks, which were thrown off from the tops of my chimnies, had reached, and found it to be 30 feet, and the height from which they fell was 32 feet. Now since bodies fall thro' 16 feet nearly in 1" of time; and the times, in which they fall through other heights, are in the subduplicate ratio of those heights; it follows, that the velocity, wherewith those bricks were thrown off, was that of above 21 feet in 1" of time: for the subduplicate ratio of 32 to 16 is the same as the simple ratio of 30 to a little more than 21. But the velocity was less at less heights: for the key before spoken of, as thrown from off a shelf in a chamber in my house, was not thrown so far, in proportion to the height thro' which it fell, as the bricks were from the top of the chimnies; and in my lower rooms nothing was thrown down, but a small bell in the garret was made to ring by it. Hence it appears, that our buildings were rocked with a kind of angular motion, like that of a cradle; the upper parts of them moving swifter, or thro' greater spaces
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in the same time, than the lower; the natural consequence of an undulatory motion of the earth.

But the agitation occasioned by this earthquake was not confined to the land: it was very sensible on the water, and even at considerable distances in the ocean. The vessels in our harbours were so shaken, that it seemed to those, who were in them, as if they were beating on the bottom. Some, that were in the bay, coming in from sea, thought they had run upon rocks or sands. One very uncommon effect of this concussion is related by several of our seafaring men, that almost immediately after the earthquake, large numbers of fish of different sorts, both great and small, came up to the surface of the water, some dead, and others dying.

The center of our former earthquakes, as well as of this, seems to have been near the river Merrimac, about the latitude of 43° north, and 40 miles north from hence; many shocks having been felt in that neighbourhood, which did not extend to this place. The late Rev. Mr. Plant of Newbury, which is situated at the mouth of that river, has given a very particular journal, in *Philos. Transact.* N^o. 462. of the shocks felt there from 1727 to 1741, few of which were perceived here or at Boston. I remember none after the memorable 29th October 1727, beside that on 30th January 1728, about two in the afternoon; and that on 5th September 1732, which, by his account, did considerable damage at Montreal in Canada, but it was very small at Boston. That also on 6th February 1737, about a quarter past four in the afternoon, which he calls a considerable shock, was perceived at Boston; and so was that on 7th
December

December following, a little before 11 in the night. From the conclusion of Mr. Plant's journal, till the earthquake which is the subject of this letter, I know of none, but that which happened on Sunday June 3. 1744, at a quarter after ten in the morning. The roar of this was as loud as any I ever heard, but the shake not so great. The day was very fair and hot, with a little wind in the morning at W. S. W. which in the afternoon came round to N. N. W. The season preceding was hot and dry, there having been no rain from 23d May. On the 1st June, at four in the afternoon, Hauksbee's thermometer stood at 5,2; on the 2d, at five in the afternoon, it was at 1, with high wind at S. W.; on the 3d, at eight in the morning, it was at 19,8; and at six 1-half in the afternoon at 3,8. From the 1st June to the 2d, at the hours just mentioned, the barometer had fallen from 29,92 to 29,82; from which time it continued rising till the 4th at eight in the morning, when it was got up to 30,12; being, at the time of the earthquake, at 29,94. The rest of the month the weather was in general very hot, with many thunder-showers.

As the late Hon. Judge Dudley, who has given a very just account of the great earthquake of 29 Oct. 1727, in *Philos. Transf.* N^o. 437, has inserted an account of the weather in the preceding part of that year; and as our last earthquake happened at the same time of the year as that did, within 8 or 9 days (regard being had to the difference between the Julian and Gregorian styles); I hope it will not be disagreeable, if I give an account of our weather the last year: in doing which, I shall follow, as near as may be,

be, Mr. Dudley's method, setting down the particulars in corresponding columns, that so a comparison may more easily be made between these two years.

WEATHER in

1727, O. St.

January and February very moderate.

Beginning of March, a great deal of snow, and some cold weather: afterwards, pleasant, rain at times, and once thunder and lightning.

April, for the most part, fair, pleasant. Plentiful rain, beginning and end of the month.

May, beginning, pleasant; then a great deal of rain; afterwards, cold and very dry.

June, abundance of thunder and lightning.

1755, N. St.

January, but especially February, very moderate.

4th of March the greatest storm of snow we had all winter. The whole month colder than February.

April, nothing very remarkable. No hot weather. Each of these four months afforded more snow and rain, than the common quantity, taken at a medium for 7 years together.

First 20 days of May, dry; 14 to 18 inclusive, uncommonly hot; latter part, frequent thunder-showers. The whole month drier than the medium.

June, ten thunder showers; 15 to 20 inclusive, uncommonly cool. The driest June since 1749.

July,

WEATHER in

1727, O. St.

July, very dry; a great deal of thunder and lightning.

August, exceeding hot and dry. One plentiful rain.

September, till the middle, very hot. More hot weather than in any summer. Middle, a violent north-east storm, with a great deal of rain.

October, a pretty deal of cold weather.

23, a great deal of rain, with the S. wind.

25, at night a hard frost.

26, Winterish weather, and a little snow.

28, Cold. Wind N.W.

29, Cold. Little wind at N.W. Evening quite calm, and a clear sky.

1755, N. St.

July, seven thunder-showers, and a little more rain than the medium.

August, not very hot; much drier than the medium.

September, variable; 10 to 14 inclusive, uncommonly hot; several other days uncommonly cool. Upon the whole, the summer rather cool than hot. The hottest weather was in the middle of May. No great rains; but rather more than the medium.

October, a great deal of cold weather. Thunder-showers on the 13th and 17th. Snow on the 20th, 25th, 29th, & 30th. But the quantity of rain and snow in the whole month less than the medium.

November began with cold and wet, there falling, in the eleven first

days 3,404 inches of rain; and on the 11th in the morning there was thunder and lightning with the rain;

rain; and at a quarter past two in the afternoon, the barometer was at 29,46; which was lower than it had been since the 15th of October. From thence, till the day of the earthquake, my diary stands thus :

November 1755.

D. H.	Barom.	Hanks Therm.	Wind.	Weather.	Rain, &c.
12 7 $\frac{1}{4}$ M	29,78	63,7	W 1	Very fair. Somewhat foggy.	,003
2 $\frac{1}{4}$ E	82	51,7	W 1	Fair.	
13 9 M	30,14	68	NW 2	Very fair.	
6 $\frac{1}{4}$ E	21	56,8	NNW 1	Clear.	
14 8 $\frac{1}{2}$ M	42	69,4	o	Fair.	
1 $\frac{1}{2}$ E	45	59	NE 2	Very cloudy.	
8 $\frac{1}{4}$ E	5	.	NE 1	Clear.	
15 8 $\frac{1}{2}$ M	4	74,6	o	Cloudy. Hazy. White frost.	
4 E	32	60,5	E 1	Very fair.	
16 0 $\frac{1}{4}$ M	27	70,8	o	Foggy.	
2 E	28	59,9	N 1	Fair.	,013
9 $\frac{1}{4}$ E	32	.	N 1	Fair with clouds. Foggy.	
17 8 M	3	70,1	N 1	Cover'd. Foggy.	
1 $\frac{1}{2}$ E	27	59	E 1	Very fair. Even ^s somewh ^t foggy	,001
18 4 $\frac{1}{4}$ M	17	74,1	o	Clear. A violent earthquake.	
8 M	16	78	o	Very fair. Great white frost.	
3 $\frac{1}{4}$ E	11	58,3	E 1	Very fair and hazy.	,017
10 E	08	69,1	o	Clear. Somewhat hazy.	

From this time the barometer rose till the 20th, when, at 8 $\frac{1}{4}$ M. it was up at 30,44, the sky covered, wind N 2. Then it fell till the 23d at 6 $\frac{1}{2}$ E, when it was so low as 28,87; which was lower than it had been since the 6th of February last. The afternoon of the 22d, and night following, when we had another shock, it was calm, and rained 1,205 inches. This leads me to observe, that though the *serenity*, as well as *calmness*, of the air, is a circumstance taken notice of in many earthquakes, both in this and in other parts of the world; yet it does

not always obtain, at least in the smaller shocks; and, so far as I have had opportunity to observe, the *calmness* of the air has more constantly attended upon earthquakes, than its *clearness*. The white frost on the morning of the earthquake, which, when melted, I found to be of the depth of $\frac{1}{1000}$ of an inch, was almost double of any white frost we have had for seven years past, and about five or six times as great as we commonly have. The barometer and thermometer underwent no alteration at the time of the earthquake: only, my barometer, which has an open cistern of quicksilver, and stood in a chamber, was so agitated, that part of the quicksilver was dashed over the sides of the cistern, and scattered upon the floor. This cistern was a cylindric cup, whose sides were an inch higher than the surface of the quicksilver.

I shall not pretend to make a comparison between the weather of the two fore-mentioned years, nor inquire how far Mr. Dudley's conjecture (*Phil. Trans.* N^o. 437. p. 66.), as to the influence of the weather in producing the earthquake of 1727, might be affected by such a comparison. I choose to leave this to you, Sir, and to the other gentlemen of the Royal Society, who, I know, are much better able to make a proper judgment in this matter; and beg leave to subscribe, with the greatest respect to that illustrious Society and yourself,

Reverend Sir,

Your most obedient,

and most humble Servant,

John Winthrop.

II. *The*