

PHILOSOPHICAL TRANSACTIONS.

Sept. 20. 1683.

The CONTENTS.

- 1 *An account of the Earthquake that happened at Oxford, and the parts adjacent Sept. 17. 1683. by a fellow of a College in that University, and of the Royal Society.* 2 *An account of the Eclipses or ingresses of Jupiters Satellits into his shadow, and such Emerfions of them from it, as will be visible at the Observatory at Greenwich in the three last Months of this year 1683. sent in a Letter to the Publisher from I. F. Astron. Reg.* 3 *An account of the cutting out the Cæcum of a Bitch, by the ingenious William Mufgrave LL. B. Student in Physick, and fellow of New-College Oxon.* 4 *Succincta Historiola de tribus Conjunctionibus magnis, Saturni scilicet Jovis, nec non Martis, Gedani. Exeunte Anno 1682. & initio Anni 1683. ad 28 Maii st. n. usque, a JOHANNHE HEVELIO observatis.* 5. *JOHANNIS HEVELII Observationes circa nonnullas occultationes Fixarum Gedani Anno 1683. habitæ.*

An account of the Earthquake that happened at Oxford and the parts adjacent Sept. 17. 1683. by a fellow of a College in that University, and of the Royal Society.

When you engaged me to give you some observations upon the late *earthquake*, which happened here at *Oxford*, the 17th of *Sept.* 1683. about seven of the clock in the morning, I hoped to have gotten a better account of it, than since I have been able to procure. For though a matter so unusual

T t

ual might be supposed to render men more curious in observing it, yet we find to the contrary, that the rarity of such effects makes many people not know what they are, and by heightning their surprize imposes upon their judgements.

For I am sensible that a great many of those, who plainly felt the shaking, and heard the noise, which attended it, did not know what to impute it to; but of those that I have discoursed with concerning it, one fancied it to be the falling of something about his house; another the tumbling of wood; a third the rattling of a cart, one *one thing*, and another *another*, till either a mature deliberation, or intelligence from other hands, convinced them to the contrary, and satisfied them that it was an *earthquake*. Even many of those, that could imagine it to be nothing else, were afraid at first to speak their opinion of it: I question not but all were very much amazed, and had they not been so, the short continuance of the trembling would hardly have permitted them to make any accurate observation.

I for my part perceived the *sound* and *motion* very plainly, and though when I saw the clearness of the morning I judged that to be an *earthquake*, which otherwise I might have thought to have been only a distant thunder, yet had I not so clear an impression of it in my mind as to make any considerable *observations* of my own; so that what I can afford you will be only some occasional reflections upon *earthquakes* in general, and some small remarques upon that little intelligence, which I have picked up here and there concerning this in particular.

1 The time in which this earthquake happened is to be observed, a time in which such effects are most commonly experienced, if we may credit *Aristotle*, who tells us that they are most frequent in *Spring* and *Autumn*; which remarque, though slighted by *Gassendus*, who generally affects to contradict that *Philosopher*, is notwithstanding confirmed by that great naturalist *Pliny*, and several other learned men in all *ages*; who do not deny but that *earthquakes* may, and have several times happened both in *Summer* and *Winter*, tho' not so commonly as in the other two *seasons*, in which there is generally a greater abundance of moisture sucked up, more *vapours* and a larger quantity of *Nitre*, as experience doth demonstrate, all which ingredients may conspire to the producing of an *earthquake*. For if we consider how capable they are of a large expansion, how forcible they are when rarified in *vessels* closed and placed over the *fire*; in *Æolypiles*, from which they break out, with forcible blasts, or in winds, which frequently

ly proceed from the rarefaction of such principles, we may suppose that those vapours, which produce such great commotions in the air, may cause a considerable disturbance in the earth, when pent and locked up by cold, or any such like accident.

2 We may therefore take notice of the weather which happened before, and at the time. Now I very well remember, that the latter part of the first week in *September* was so rainy, that most people were apprehensive of a *flood*, and upon *Sunday* the 9th of *September* there fell some very considerable showers in the afternoon, but from that time it cleared up, and to the end of the next week continued very warm and pleasant weather, as I remember by a great many circumstances. The pleasantness of the evening inviting me to walk out with some friends, upon *Sunday* the 16th day, as we came home we perceived it very chilling, and inclinable to frost; nay some in the company fancied they saw a little skim of *Ice* arising upon the water; the next morning it was found to be a very hard frost for the season, and then about seven of the clock, the day being very clear and calm, the *earthquake* happened. The like observations of cold preceding are in *Dr. Wallis* account of an *earthquake* n. 10. of the *Philosophical Transactions*, as also in that of *Mr. Boyle* n. 11. concerning the same *earthquake*, which happened in an *evening*, as this last did in a *morning*, and it hath been an old * observation that they happen most commonly at such times.

3 The height of the *quicksilver* in the *Barometer* was as considerable at the time of this *earthquake*, as that which they described, I could not for want of a *glass* take notice of it myself, but I am told by the *Operator* in *Chymistry* here, that It stood as high then, as at any time these three years; which together with a remarkable calmness of the air, a matter generally looked upon as one of the circumstances, which accompany *earthquakes*, and by many reckoned amongst the *signs* which forerun them, may be sufficient to shew how free the air was from *vapours* at that time, and surely the fewer there were above, the more may be supposed below.

4 It may not be improper amongst other circumstances to take notice of those *ignes fatui*, which were frequently seen a few days before this *earthquake* happened; for I am credibly informed by some, who were eye-witnesses, that they saw two at once as they were walking one night, and that several persons had at other times observed the like; which may pass for a probable argument, at least, to shew how full the *earth* was then of damps

and *exhalations*, since a stench, that hath tainted *well water* after an unusual manner, hath upon the same account been generally reckoned amongst the signs of an *earthquake*, by which it may be predicted: for by this it was that *Pherocydes* is said to have prefiged the *earthquake* of *Lacedemon*, and *Helmont* mentions another who pretended to the same foresight, by tasting the water of a very deep well in the *Castle* of *Lovain*.

5 But to proceed to the *earthquake* it self and to describe its motion, it was not of that sort, which are termed *pulses* or *succussions*; such as strike the ground at *right angles* with a violent shock or intermittent knocking, so as oftentimes to raise the earth to a considerable height, or force their way by a breach; it appears rather to be a *trembling motion*: yet was it not of that sort of *tremors* that are called *Incliners*, such as strike the earth at *acute angles*, or a slope, such as make it to lean sideward, like a ship that is under sail (to use an old comparison) and consequently such as frequently overthrow buildings, and work mischiefs of that nature: But this which I am describing was of a third sort of *earthquakes*, according to the general distinction, such as vibrate and shake without altering the position of the *earth*, and leave all things in the same posture in which they found them. For it shook the *earth* with a tremulous and vibrating motion, whose reciprocations were repeated with a great deal of quickness. The pulses (I mean such as must of necessity be in all vibrating motions) were as I could perceive a little discontinued, and yet they came so thick that I could not count them, tho the whole *earthquake* continued here scarce more than 62ds of time, and when that ended the *motus restitutionis*, or settling of the building in which I was, did seem to be with a crash.

6 Now astremulous and vibrating motions are proper to produce sounds, so was this *earthquake* accompanied with a hollow murmuring sound, like distant *thunder*, as I have observed before, which sound kept time so exactly with the motion, and was so conformable to it in all respects, that it plainly appears, there was the same reason for both: Nay this sound was varied by the very same accidents, that the trembling was; for to those that were within doors it appeared to be more considerable, and as it were in the air above, occasioned chiefly by the shaking of the building, as we may guess by a blow or stamp in a room, which besides the principal sound from the part that is stricken, causes another obscure one, together with a small shaking throughout the whole. And I doubt not but such sounds and shakings may be diversly modified,

dified, according to the different contextures and forms of buildings, as for instance in arched fabricks the trembling may be more uniformly vibrating, and the sound more considerable, as the air included is capable of more undulations, which I presume may be the reason why you heard it so loud in the *Laboratory*; for it is certain that all other sounds have a great advantage there.

7 But those that were abroad in the fields and open air, perceived, with a gentle shaking, a hollow murmur towards the surface of the earth, not unfitly compared to the groaning of some planks of Elm, Ash, or Firr when the application of fire, to the wood by rarefaction excites a motion in the air and watry parts contained in the caverns or air vessels, lying like so many little wind pipes (*vid. Dr. Grews Anatomy of Plants li. 3. c. 7. §. 7.*) so as to shake the ligneous fibres, and cause both a trembling, and sound: the comparison, tho seemingly trivial, may be more considerable, than he is aware, that shall despise it, if he make an allowance for the different quantity and contexture betwixt the board and the earth, together with the various application of the heat, which in the one case is outward, and in the other is supposed to be internal.

Now that that there is considerable heat within the earth is manifest, from the experience of *Miners* working in the deeper grooves, of which you may read more in Mr. *Boyles* treatise of *subterranean qualities*: from those hot springs which break out thence, from fermentations occasioned by *mineral* spirits, and to give a vulgar instance from the mixture of quick lime and water, together with several ebullitions in diverse *experiments* too commonly known, and too many to be here inserted. Nor is it less commonly observed, that such heats and fermentations within the earth are augmented by frosty weather, when the steams being more pent up, and hindered from breaking out, do work more forcibly upon one another, as I have hinted before.

And that sounds and tremblings may be produced by such heat, though it did but work upon *air*, *watery vapours*, or *nitre* only included in pores and cavities, appears by several *experiments*, as that of filling glass bubbles half full with water and *nitre*, which being set to the heat of the fire will tremble with a sort of humming sound, and after that break with a great deal of noise and violence; but those vulgar observations, of green wood burning, or water boiling in a covered vessel, may be sufficient for our present purpose.

8 By what analogy this of ours may be best explained I shall not
yet

, or determine, but its found, as well as its trembling appears to be the same in most of those places, where they were perceived, as I have learnt by a considerable enquiry; from whence we may infer that they were not caused by the falling of earth or rock from the upper part of some cavern; nor from any commotion of vapours within the hollow, as powder works in a mine, by which similitudes it is usual to expound some *earthquakes*; for then it would have been perceived more plainly in the places above it, or those that were near adjoining and not equally considerable in towns of such various distances, as *Oxford, Burford, Watlington, Benson; Brill and Alisbury in Bucks: Wallingford, Radley, Appleton* and some other places in *Berkshire*, with many more round about from whence I have had information.

9 Yet tho it was the same in the main, I cannot say but in some places it was less considerable than others, for I find that the men of some towns speak dubiously, especially towards the north of *Oxford*, and some talk of a neighbouring town feeling it, tho their own did not. One knows not how to believe the countrymen that are oftentime unobserving, or otherwise I should affirm that it was not at *Kirtleton, Glympton, or Ascot under Whichwood*: but whether it was, or was not, or not so plain in some places, as it was generally in its circuit, the matter is not much, for it only argues that some places are not so apt to be shaken as others, of which your own reason may inform you as well as all the *naturalists*, that have written upon this subject.

Yea, even here in Town the *earthquake* was not perceived so plainly in some places, as in others; but that may depend upon circumstances, as the position and form of the houses, or some accidents, as noyse or Carts intervening, which might render it less observable. Besides, I do not deny but there may be some *Cuniculi*, little passages or hollows here and there under ground, which might advantage the trembling, and elsewhere more solid parts which might damp and obstruct it: Nay, I believe, if one should dig deep in any two places he would hardly find them to be exactly alike.

10 This might occasion some difference in the found too, and I remember one that was walking then, informed me, that he perceived it like a voice under ground, but he could not tell which way it passed, perhaps there might be a *cavern* there. Another report of that nature I have heard as from one that was travelling over *Shotover*, and it is very likely that there are considerable hollows there.

Accord-

According to this account the *Elm planks* mentioned Obs. 7th may be a proper similitude, but I have informations from one in *Town* that was fishing in the *Charwel*, that whilst his boat trembled under him, and the lesser fishes seemed much affrighted by an unusual skipping, he heard the *murmur* as of a rising wind, which he fancied just then breaking out, and rumbling upwards, but felt none. The like relation, as to *rumbling* in the air, I have from good hands concerning some people that were in *Dourton* park in *Buckinghamshire*, which I mention only for the distance sake, for most hereabouts agree in the same fancy, though at first some thought the rumbling might proceed from a Cart, but they could not discern which way it went; I my self perceived it like distant thunder, a noise determined to one place, not fleeting or passing from me, tho' the crash which ended the shaking of the building a little deceived me in my first imaginations.

Upon all which accounts it seems to me that the mode of its tremulous and vibrating motion, together with its sound, may be best explained by those effervescences mentioned in the 7th Obser. and I believe you may have a great many more instances from your *chymical operations*, particularly in drawing off the spirit of *Nitre*, with which *Lemery* will allow the third part only of a retort to be filled for fear it should break asunder.

But to stick to the most common instance of water seething in a covered vessel, we find the *Ancients* described a sort of *earthquakes*: by this very *analogy*; and *Aristotle* in his book *de Mundo*, where he gives them seven appellations according to some accidental affections, whereby they may be distinguished, calls those of this kind by the name of *Βράουσι* as if they boyled, because they ply up and down: I know that some may interpret such a one to be a pulse, but when I said that ours was none, I distinguished it from the other, according to the common way, by a different mode in their motion as they affect the sense, which now to explain more fully, I take this that happened here to be no such forcible, or irregular *ebullition* raising the earth with intermitting shocks, as that of *Mechlin* for instance *April 4. Anno 1640.* described by *Van Helmont*, but a regular effervescence of inclosed vapours more evenly dispersed, working up and down the earth with a trembling of each part, and a reciprocal agitation of the whole, for so it was perceived.

II This explication seems to be the more probable, because I could never yet meet with any, who pretended to determine from what part this *earthquake* came or whether it went, and if any one

had but a fancy as to this matter, the next that I met with had another to contradict it, which argues that it did not pass sloping like a train, impressing a motion upwards, at the same time that it shot it self across the earth through the cavities below. For then it might have been perceived to pass forwards, as well as that described in the *Transaction*; n. 10. was at *Bletchington*, tho not so plainly, at that terrible one, which happened in *Calabria*, *March 27. Anno 1638.* described by *Kircher* (*præfat. ad mundum subter.*) where the *Author* perceived it coming towards him with an hideous bellowing, as from the *Island Strongoli*, and describes those *cuniculi*, through which it passed, affirming that he guessed at them before. li. 4. §. 2. c. 10.

Notwithstanding I cannot say, but that some parts of those damp and vapours, which we suppose to have caused our *earthquake* here, might be rarified before others, and so the motion be carried on below for a while, until they were able to produce an uniform shaking upwards and above.

12 The time of the day, at which this *earthquake* happened, passes for the same in every place, that felt it; all say about seven a clock: but I dare make no inference from hence, that the shaking really was in all places at the the same time, unless the time had been exactly observed, to a minute at least, in several places. For since all tremors and sounds, as well the greater, as less, are found to move to an equal distance in an equal time; moreover since the sound of a small gun, as well as that of a Cannon, for instance, moves 230 *Orgye Parisine* or *hexapodes*, i. e. 460 yards, in a second, as appears by the curious experiments of *Mersennus*; it follows, that all sounds will move above 15 miles in a minute, and above 940 in an hour, and consequently the trembling of the earth passing along with a continued noise, may be supposed as quick in its motion, and so it hath been generally experienced in all earthquakes.

I know not therefore what to judge, as to the motion of this *earthquake*, by so rude an account of the time, nor can any thing be inferred from the most exact observations, that have been made in this town singly, they are indeed to be commended, and I could wish, that for the future learned men especially would be more curious in this matter, since several considerable conclusions may be drawn from thence. And to shew what it is to be mistaken in a minute, let us admit, what hath been disproved by the 8th Observ. that this *earthquake* was caused by a violent concussion of any particular place, and that the trembling was thence, as from a point dispersed round about it might accord with a uniform calculation in a minutes distance have reach'd the extremity of its Sphere of compass.

13 For the circuit of this *Earthquake* was but 70 miles, or thereabouts ; its largest extent was from *South E.* to *Nor. W.* the least from *N.* to *S.* as will appear by the following account of its compass, the best that I could procure, it was perceived a little short of *Kirklington N.* of *Oxford*, at *Blechington* and at *Alysbury S. E.* where it was perceived very plainly ; as also at *Thame* which is *E.* and so at *Aston*, *Kinson* and *Stoken-Church hill*, as one that was then travelling over it informed me ; in like manner at *Watlington S. E.* (some say at *Reading* which is more *S.* and then its compass may be supposed larger) at *Wallingford S. E.* and by *S.* as much as any place ; at *Abington S.* but not much ; not so far as *Farington S. W.* but at *Bampton W.* at *Burford* to the *N.* at *Lo. Hanborough N. W.* not much ; at *Woodstock* which is more *N.* little or none ; and at *Glympton*, two miles beyond it, not at all, as I am informed.

Thus far have I traced this *Earthquake* through part of *Oxfordshire*, *Bucks*, and *Berkshire* a very inconsiderable space if compared, with that, which others have taken up, as for instance, the *Earthquake* which happened in the South parts of *Norway*, *Ap. 24. Anno 1687.* one hundred and sixty miles in length and so much in breadth, contrary to the nature of all those *Earthquakes*, that ever I read of, saith *Michael Peterfon Escholt*, that describes it, but *Kircher* mentions one 200. miles in length *Mund, Subt. li. 4. Sect. 2. c. 10.*

14. The effects too were very inconsiderable, as shaking down some Pewter in a very few places ; casting out a Truckle-bed westward, which when I looked upon I found so very easy to move, and apt to run, as also the room so smooth and declining towards that point, that I could as little infer from thence, that the motion came this or that way, as from the falling of many books from the North side of a Warehouse, when a few only fell from the South.

Now in other countries there have been *Earthquakes*, which have produced the most dreadful effects, overthrowing some *Cities*, and swallowing up others ; ruining whole *provinces*, and destroying many thousands by those pestilential vapours, which they exhale, but God be thanked this country has generally been free from such mischiefs, which argues a lesser number of clefts and caverns, fewer mines comparatively, and a smaller quantity of *Nitrous sulphureous*, and other such turbulent matter, as well as *Mercurial*, *Arsenical*, and other such dangerous steams.

And of what ever nature the inclosed vapours were, which caused our late *Earthquake*, it seems as if they were not able to force their passage through the earth (unless any one shall fancy that they

steamed out by little and little dayly, when the Sun resolving the Frost had opened them a passage, through which they might gently expire, so as to cause some Breezes of wind towards the mid time of the day) for the air remaine but little disturbed, and the weather continued fair untill the end of the week, though the *earthquake* happened upon monday morning, nor shall I pretend to determine, whether yet they have found any vent or no, tho the week ensuing was very windy and boysterous, but I thought my self the rather obliged to take notice of this passage, because I find that a suddayn change of weather has followed several *earthquakes*, as for instance that which happened here Jan. 19. Anno 1655. according to a particular remarque of Mr. *Boyle* in the account, which I have had occasion to quote before.

15 For the same reason that we have *earthquakes* not so dreadful, as in other countrys, we have them not so frequent, some places are scarce ever free from them, as *Seneca* saith of *Calabria*: fifty seven times in one year they heard of them in *Rome*, sayth *Pliny*; nay they have continued many days together. We have not had one here before for almost a score of years, except that which happened about 4. a clock in the same morning with the last: we have it confidently avouched, that there was such a one, but being in a manner of the same nature, and not observed by me, nor much talked of by others, I shall take no farther notice of it; but conclude this observation with a remarque concerning *earthquakes* in general: That seeing the earth abounds with such great variety of matter, which may produce them, as also with so many caverns and chinks of such various figures, through which they may be agitated with such different motions, it seems more easy to shew how they may begin, how they may be carried on, how they may produce such different effects, and how they may continue; then to determine why they should happen so rarely, doe no more mischief, or be stoped so soon in their motion.

16 As for this *earthquake* in particular I have spoken of it according to the best intelligence, that as yet I have been able to procure, from every part of this town, most places of the country round it, as well as some in other countrys, and could have given you a great many more passages and relations, if they had not been needless as being all to the same effect. I have heard also a great many flying and idle reports, of *Scholars* that were then at prayers, running out of such and such *Chappels*; of more then ordinary effects in certain houses, of persons that had seen it moving along some buildings, crossing the street, and such like, which have cost me the pains of disproving them. On

On the other hand I have met with a great many different fancies and conjectures, according to the different circumstances of those that were then got up, and those that were not. I found by a great many enquiries that the latter had various impressions, according to the position of their beds to a wall on this or that side, and that out houses allways seemed to receive the shaking from those that were adjoining, that people walking perceived it not in the same grounds, in which those that were working or standing still did feel it plainly; that in some grounds, (as those behind St. Giles) the shaking was perceived and not the sound. I have heard also of some persons deceived by the sight, which made them fancy it came from that part, which was opposite to them, and so to glance as their eyes did, tho I have found a great many reports of this nature false, by enquireing of those persons, upon whom such observations have been fathered.

In short, I found so hard a task in occurring to different imaginations and circumstances, that I should scarcely have finished this relation, if it had not been to approve my self,

SIR,

Your humble Servant

T H O. P I G O T.

P O S T S C R I P T,

Since the slowness or other employment of the Press has put back your Transactions for September to the latter end of October, I shall take notice of another Earthquake far more considerable than this which I have described, upon all accounts; it happened Oct. 9. about a 11. at night and was in Oxford shire northwards very much, some say they felt it here. It spread over all the midland Countys, and extended into Derby shire, in which, as in the coal countrys it was very violent. They report that it was in all its several places at the same time, not determining precisely, and that it produced some remarkable effects. But this is a subject which deserves a large description, with which I hope that some person of your acquaintance will oblige us.

