Seismological Investigations.—Fifteenth Report of the Committee, consisting of Professor H. H. TURNER (*Chairman*), Mr. J. MILNE (*Secretary*), Mr. C. VERNON BOYS, Sir GEORGE DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Dr. R. T. GLAZEBROOK, Mr. M. H. GRAY, Professor J. W. JUDD, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, *and* Mr. NELSON RICHARDSON. (*Drawn up by the Secretary.*)

[PLATES I AND II.]

CONTENTS.

I. *General Notes.*

THE following notes, which have been brought together to form the fifteenth Annual Report of this Committee, refer for the most part to work which is in progress rather than to work which has attained a stage approximating completion.

Your Committee ask to be reappointed with a grant of 60*l*.

Registers.—Since the meeting of last year Circulars Nos. 20 and 21 have been issued. They refer to observations made at Shide, Kew, Bidston, Edinburgh, Paisley, Eskdalemuir, Haslemere, West Bromwich, Stonyhurst, San Fernando (Spain), Valetta, Beirut, Ponta Delgada, Cape of Good Hope, Mauritius, Cairo, Bombay, Kodaikanal, Alipore, Colombo, Irkutsk, Tokio, Batavia, Toronto, Victoria, Baltimore, Trinidad, Chacarita and Pilar (Argentine), Honolulu, Perth, Sydney, and Christchurch.

Visitors.—Although many visitors have called at Shide Observatory merely to satisfy curiosity, there have been a number who have visited this station with the express object of obtaining information which they could turn to practical account. The following gentlemen spent two days at Shide to study the routine of a seismological observatory: N. K. Fennimore (St. Helena), C. E. Pain (Seychelles), F. Marx (Ascension), J. G. Meats (St. Vincent, Cape Verde), H. G. Thomas (Cocos), C. E. Holmes (Fernando Norhona), R. Rankine (Fiji), J. J. Shaw (West Bromwich), F. Ryan (Electra House, London), the Rev. A. L. Cortie, S.J. (Stonyhurst). Other visitors practically interested in seismology were F. E. Norris (Guildford), G. W. Walker (Eskdalemuir), W. E. Cooke (Perth), Major A. E. Galbraith, R.E. (Osborne), Lieut. W. A. Moore, R.A. (Freshwater), Professor F. G. Baily (Edinburgh), Professor H. H. Turner (Oxford), and M. H. Gray (Abbey Wood). W. R. Hearn (Consul-General, San Francisco) and Professor E. F. Pinto Basto (Coimbra) both gave assistance towards obtaining material for a catalogue of destructive earthquakes. In addition to these individual visitors, Shide was visited by several parties, the Lymington Natural Science Society, some twenty visitors from Rouen, Professor Vèlain with his assistants and a number of students from the Sorbonne. These latter took a keen interest in everything they saw, and were particularly struck with the method followed by the British Association in making seismological observations as contrasted with the method which is now in process of extension in their own country. From Japan we were visited by Count Otani Kodzui and two of his assistants, who had just returned from Central Asia, where incidentally they had observed large earthquakes. Their records were compared with those obtained at European and other stations. Professor H. Nakano very kindly offered to give us such assistance as he was able in obtaining more complete records from Japan. I may add that for a considerable time past we have been indebted to Mr. J. Rippon, of the West India Cable Company, for registers of earthquakes which have occurred in Jamaica.

II. *New Stations.*

Installations are now in working order at West Bromwich and Guildford, and shortly we expect to receive a large series of records which have been made from Melbourne. Through the kind co-operation of the Eastern, Eastern Extension and Pacific Telegraph Company, instruments will very shortly be established at St. Vincent (Cape Verde Islands), Ascension, St. Helena, Seychelles, Cocos and Fanning Islands. Other cable companies are considering the advisability of establishing instruments at certain of their stations, whilst, largely in consequence of the interest taken in seismological observations by Sir Everard im Thurn, an instrument will very shortly be shipped to Fiji. Inquiries have also been received respecting the installation of seismographs in several other colonies. New recording instruments in which the paper moves at the rate of 240 mm. per hour have been adopted at the Royal Observatory, Edinburgh; by the Geographical Society, Lima, Peru; and at

Stonyhurst College, near Blackburn. New instruments with quickly moving record-receiving surfaces have been sent to the Instituto y Observatorio de Marina, San Fernando, Spain; the Rio Tinto Company, Limited; Huelva, Spain; Cardiff; and Adelaide.

West Bromwich, Hill Top.—The instrument established by Mr. Shaw at this station has two pendulums: A, with the boom-point to the east and weight to the west; B, with boom-point to the south and weight to the north. These are suspended from the walls of a cellar excavated in hard gravel. In descending order the strata beneath are 105 feet of clay and red sand, 108 feet of clay, clunch, and coal, 60 feet of white rock, 63 feet of rock binds, and 31 feet of coal. The weights are 100 kilos. each. Period 16 seconds. The weight on A is 36 inches from the boom-point, whereas the weight of B is 54 inches from the boom-point.

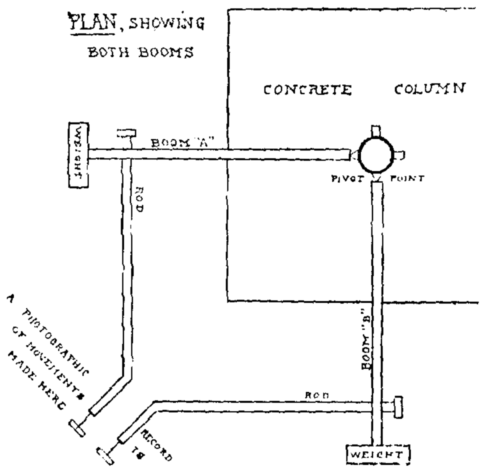


Fig. 1.

Both booms are fitted with multiplying levers (ratio, 20: 1) giving a total sensibility for A 0″·1 tilt = 1 mm. amplitude; and for B 0″·15 tilt = 1 mm. amplitude.

The records are taken on smoked paper travelling five inches per hour.

The time is recorded by electric signal each minute, and the governing clock compared with Greenwich daily. Average variation about one second per diem.

Guildford, Woodbridge Hill.—This instrument was designed and put up by Mr. F. E. Norris. The mast rises 4½ feet above the top of a concrete column, which is sunk 5 feet in London clay. There is a north boom (A) and a west boom (B) recording without multiplying levers. Length of boom, 3 feet; weight at outer end, 100 lb. 1 mm. displacement = 1″·88 arc.

Instruments in Jamaica (for local shocks).

1. *Chapelton (M. Maxwell Hall).*—A duplex-pendulum seismometer. Heavy weight, about 30 lb. Multiplication about 10 for horizontal movements only. Records on top upon a smoked-glass plate.

2. *Kingston (Brennan).*—Made after the pattern of Gray, of Glasgow. A heavy weight ring about 9 inches diameter, 25 lb. weight, acts as a pendulum, with 'dampers' to prevent continued oscillation termed 'friction pointers.' Multiplication about 12. Records upon a smoked-glass plate below, same as described in Milne's book on earthquakes. All enclosed in a case free from wind currents. Length of suspension about 5 feet.

Verbeck's Ball and Plate Seismometer.—Described in Milne's book. Consists of two plates of glass 2 feet by 18 inches by ½ inch, about 25 lb. each, separated by three ¾-inch steel bars horizontally fixed. Registers on the top surface of top plate. This will give the *actual* horizontal movement of the ground, and is intended for large earthquakes. Can register a movement of about 2 or 3 inches. Fixed firmly to the ground and protected from air currents.

III. *Distribution of Earthquakes in* 1909.

The dash-dot lines on the accompanying chart (Plate I.) are parallel to the axes of districts from which large earthquakes have originated. It will be observed that they follow the principal ridges and troughs on the earth's surface, but not necessarily to their extremities.

In the Pacific the lines P, E_1, A_1, A_2, B, D_1, and D_2 follow the lines of troughs, while the remaining lines in the same ocean follow ridges. In the Atlantic the eastern portion of C_1 and H are ridge lines, whilst the western portion of C_1 is the portion of a trough.

In Africa K_8 is a ridge, whilst O and its northerly continuation to the Jordan depression is partly a trough.

In the Indian Ocean part of G_1 and G_2 are parallel ridge lines, whilst F_3, F_2, M_1, and R are troughs.

The lines in Europe and Asia follow ridges; K_1 is the Tian Shan-Altai system, which is continued to the north-east by the Stanovoi-Yabolonoi ranges. From this north-eastern extension, however, but few earthquakes originate. K_2 is the Kwen Lun system, which ends abruptly at the great plain of China or turns at right angles near the great bend of the Hoango Ho and follows the fold of the Khingan Mountains to the northern bend of the Amur. K_7, K_4, K_3 is the Alpine, Balkan, Caucasian, Himalayan system, which turns sharply round the eastern bend of the Brahmaputra, and as the Arakan Yoma range runs down to Cape Negrais, to be continued by stepping stones, the Andamans and Nicobars, to join the Sumatra-Java volcanic ridge.

The number of earthquakes which have originated from each of these districts in 1909 was A, 4; B, 3; C, 0; D, 6; E, 18; F, 24; G, 3; H, 2; J, 0; K, 25; L, 0; M, 13; N, 0; O, 0; P, 0. The total number of earthquakes since 1899 from these same districts, therefore, becomes A 40; B, 55; C, 30; D, 28; E, 133; F, 175; G, 26; H, 35; I, 5; J, 5; K, 141; L, 2; M, 86 (this includes small disturbances); O, 1; P, 0.

The most pronounced megaseismic activity is at the present time along a band running from the south extremity of the Philippines and Java in an east-south-east direction towards the middle of the Pacific. In the islands which stud this band with their intervening troughs we see the outcrops of mountain ranges with Himalayan proportions. It suggests a continent in the making.

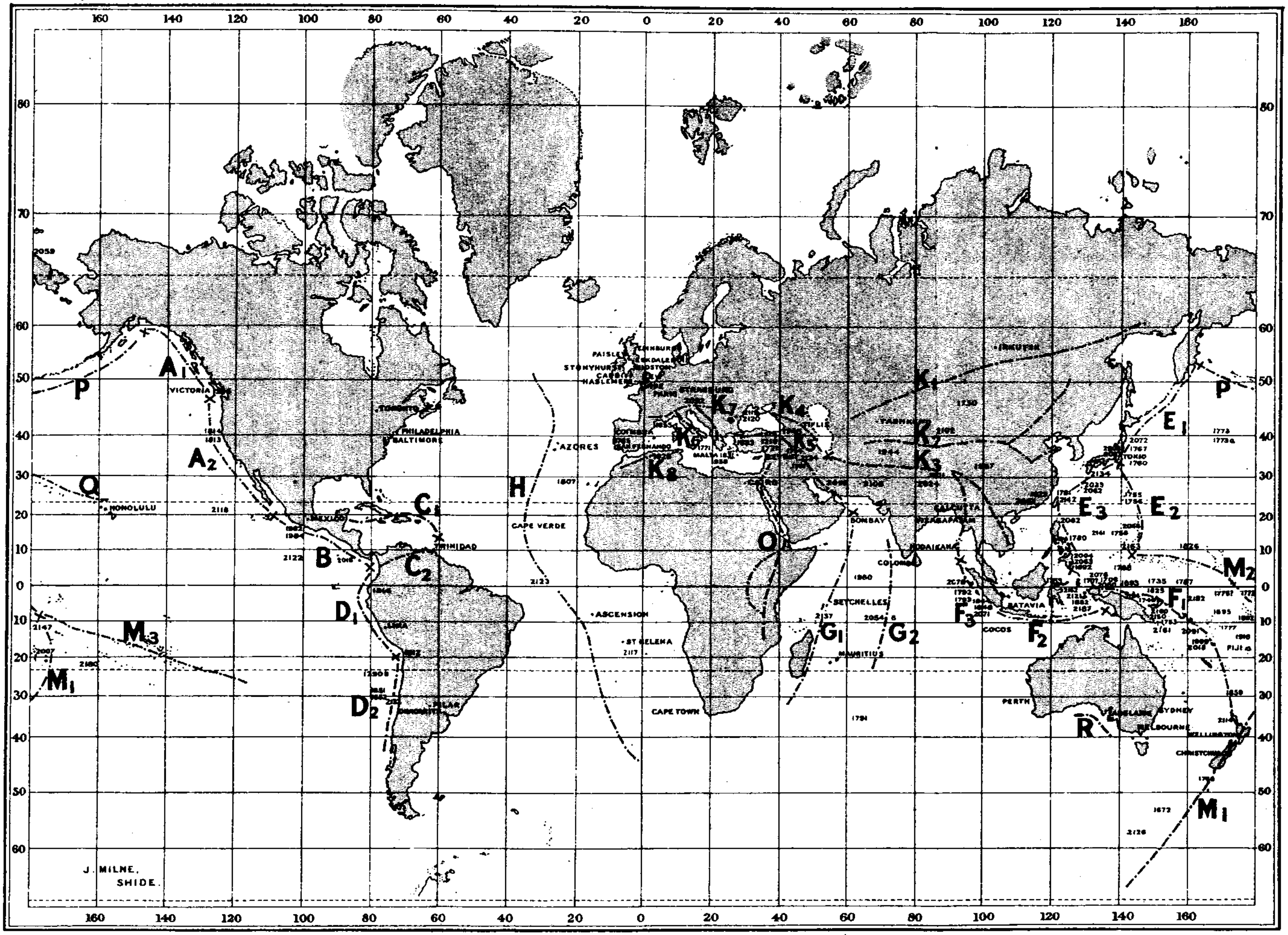
IV. *A New Departure in Seismology.*

In the British Association Report, 1908, p. 64, I showed that after the earthquake of January 14, 1907, which devastated Kingston, Jamaica, 51 of the after-shocks were recorded by the British Association type of instrument at several stations in Great Britain. The time taken for these to travel from Jamaica to Great Britain, a distance of 67°, was in all cases practically 43 minutes. I am not aware that any one of these 51 shocks was recorded by other types of instruments either in Britain or Europe. Previously to this, however, very large shocks had been recorded as thickenings of traces near to the antipodes of their origin, but this was the first time that small after-shocks had been noted at places far removed from their epicentral areas. We have here not only an indication of the high degree of sensibility possessed by a certain type of instrument, but a suggestion that a new field for exploitation had been discovered. Observations corresponding to those made on the shocks from Jamaica have been frequently repeated, with the result that the registers from stations possessing different types of instruments show considerable variation in the number of records which they yield. For example, between July 1 and December 31, 1909, we find that in the Isle of Wight 279 earthquakes were noted. These are assumed to be of true seismic origin, either because each finds a corresponding record at several other stations, or that they were noted at times when we should expect the surviving efforts of large earthquakes to arrive in Great Britain. During this period, at Hamburg, Strassburg, and Laibach, where other types of instruments are in use, the number of records were respectively 123, 64, and 42. At these latter stations, like many others in the world, we find either instruments recording on smoked paper or instruments which recorded photographically. In the former the writing pointers are connected with the bob of a pendulum by a system of levers which gives a high multiplication, whilst with the instruments which record photographically the source of light is at a considerable distance from the record-receiving surface. With the first type of instrument a slackness in joints, together with elasticity and inertia of the levers, results in a loss of motion. Where the multiplication is high the makers of these instruments tell us that this amounts to five per cent. This means that no record whatever can be obtained until a certain amplitude of motion

P. 48a

The Large Earthquakes of 1909.

Origins for 1909 are indicated by their B.A. Shide Register Number. The Axes of Earthquake Districts are indicated A, B, C, &c.



Illustrating the Report on Seismological Investigations.

has been reached. This accounts for the fact which has so frequently been confirmed by my own experiences that this type of instrument fails to record very small movements. Why the second type of instrument carries the same objection is not so clear. We frequently notice that the traces from these instruments are not only broad, but they are wanting in definition. Small movements may possibly be lost in the ill-defined edges of the trace.

On December 28, 1908, Messina and Regio were ruined. Eight of the after-shocks reached the Isle of Wight, but only two of these seem to have been recorded at Laibach, Göttingen, and Hamburg, which are nearer to the origin than the Isle of Wight.

A similar story is told in all the registers published since 1907. Earth messages appear to be passing beneath observatories all over the world, but their existence is not recognised, because the instruments generally used are not capable of recording the same. To exploit this new department in seismology old types of instruments will have to be improved or new ones adopted.

V. *Changes in Level accompanying certain Earthquakes.*

All geologists are familiar with the enormous mass displacements which have accompanied very large earthquakes, particularly in the vicinity of their origin. It does not, however, appear to have been recognised that small changes in level may sometimes be detected at great distances from the same. Evidences of such changes are occasionally to be seen in the records obtained from horizontal pendulums. As an illustration of this I will refer to the earthquake of January 22, 1910, which had its origin to the north of Iceland. With the maximum motion of this disturbance at Shide, in the Isle of Wight, the booms of five horizontal pendulums were suddenly displaced from their normal position. Those oriented east and west were swung to the north, whilst those at right angles to the west. Pendulums in rooms 80 yards apart were displaced similarly. In their new positions they were all free to swing. The displacement took place at 8 A.M., but at 12.45 they crept back somewhat intermittently towards their original zero. This they reached at 4 P.M. The behaviour of pendulums at Bidston and West Bromwich suggested a displacement similar to that at Shide. In the seismograms which I have accumulated during the last fifteen years I find many repetitions of a similar phenomenon.

VI. *Changes in Level due to Tidal Influence.*

Towards the end of last year it occurred to Professor Milne that the conditions under which the earthquake records were made at Bidston might be utilised to determine the amount of deformation of the earth's surface due to the accumulation and removal of a heavy load of tidal water.

A few years ago, in the basement of the Victoria Club at Ryde, Professor Milne made some observations with this in view. Contrary to expectations, it was found that when the tide rose the strand rose also. This was attributed to the banking up of drainage from the land and the consequent bulging up of the same. It was, however, pointed out by Sir George Darwin that the greater quantity of water in the English Channel might more than counterbalance the effect of the smaller volume in the Solent.

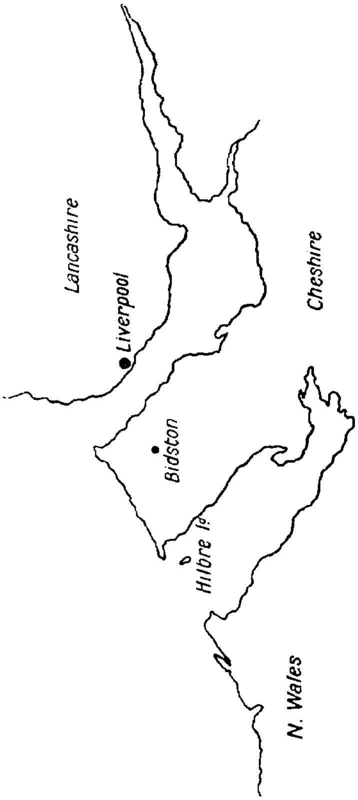
In the Mersey, as shown by the tide gauges on the Liverpool Landing Stage, the variation in the height of the tide can considerably exceed 10 feet, and in the Dee, at Hilbre Island, the oscillation is practically the same. The difference in the time of high water at these two stations is about half an hour. Consequently, as a glance at the rough map of the coast-line will show, there is a tendency for the load to balance on the east and west sides, while on the north and south, apparently, the difference would be most marked. In these circumstances it is a little difficult to determine what would be the most appropriate azimuth to mount the pendulum, but as the boom in the original seismometer was placed north and south, in the new instrument the direction was made east and west. The seismometer can, however, be turned through any angle if it be felt desirable to continue the investigations.

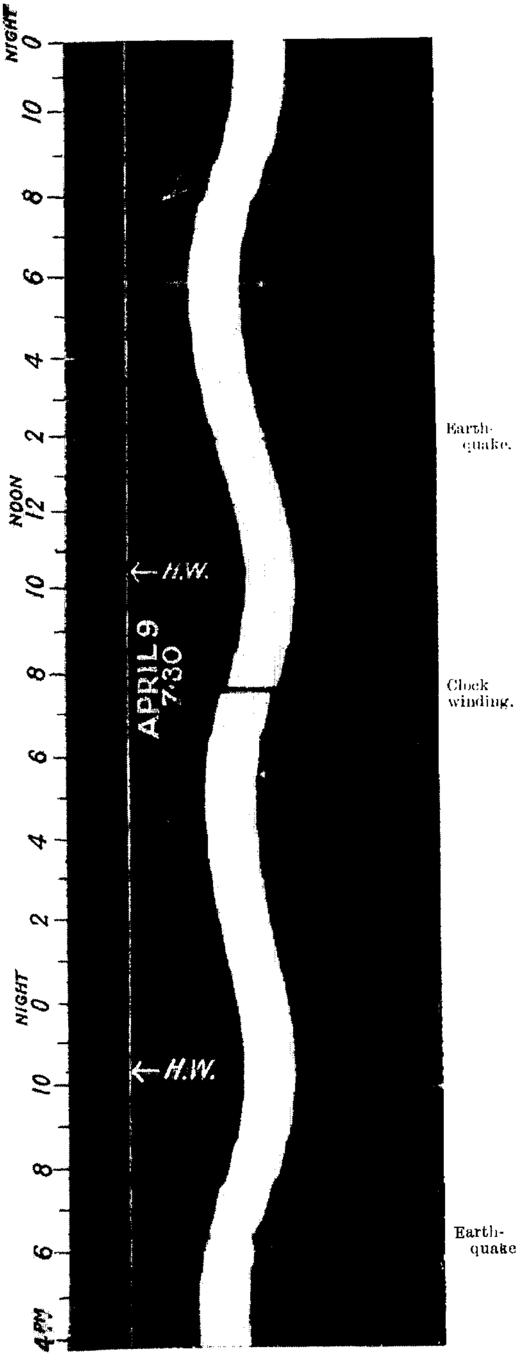
The instrument used was designed by Professor Milne and his assistant, Mr. S. Hirota. All the observations were made and discussed by Mr. W. E. Plummer, Director of the Bidston Observatory.

The boom differs in some essential particulars from the type ordinarily used in the Milne seismometer. It is divided into two parts: one, nearer to the stand, consists of a stout brass rod, carrying a weight of about seven pounds. At the extremity of this rod, which is only about 30 inches in length, is placed a light magnifying style, independently carried, and attached to the boom proper by means of a magnetised needle, capable of moving between a slender iron fork. The sensitiveness of the instrument can be increased at will by reducing the distance between the pivot on which the magnifying style works and the end of the boom. In the original construction the multiplying arm was 10 inches long, rotating about a centre 1 inch from the end of the boom, consequently the displacement was magnified ten times. The arrangements for photographing the movement were of the ordinary character. The sensitised paper was paid out at the rate of 5 millimetres an hour, so as to make the small amplitude of the oscillation apparent. The tidal displacements were sufficiently noticeable, and the accordance with the time of high water was satisfactory. To increase the sensitiveness of the instrument so as to make the motion more distinct and easily measured, and to remove any danger of the needle failing to engage the steel forks, it was felt desirable to adopt a different method of connection. With this view, Professor Milne suggested that the magnetised needle should be removed and the multiplying piece mounted as a bifilar pendulum, an arrangement which allowed the centre of motion to be brought much nearer to the end of the boom and gave a multiplication of about forty times. The method of photographing the point of light was changed, and a thin strip of black paper substituted. This apparatus has been in use since March 1910, and generally works

P.50a

Map showing position of Tidal Water round Observatory.





Deflections recorded at Bidston due to Tidal Load.

Illustrating the Report on Seismological Investigations.

satisfactorily. The diagram (Plate II.) shows the character of the photographs that are now being taken. The instrument is not well adapted for the record of earthquake waves, but two small tremors are shown; the second one is not to be found on the ordinary earthquake film.

Some difficulties have been introduced by the greater sensitiveness, and some were made more apparent, but these will probably disappear with greater experience. One difficulty was to determine the linear displacement of the boom due to an angular tilt of the instrument, for the smallest angular motion which it was possible to make with accuracy moved the multiplying style off the scale. It seemed necessary to reduce the sensitiveness by a known factor—that is, by increasing the distance between the supports of the bifilar portion. There are objections to this plan, and up to the present the results have been left in the form of the actual measured displacement. Another difficulty arose from a long slow movement of a very minute order in one direction, probably masked in the less sensitive instrument, but now distinctly noticeable in a continued series of observations. To explain this creeping it may be mentioned that the whole seismometer is mounted on a slate slab on the top of a drain-pipe, two feet in diameter. This form of stand was preferred by Professor Milne, because it avoided the drying of mortar or cement, which, in a brick-built pier, would take a very considerable time. The observed creeping may be due to some motion of the stand or of the hill on which the Observatory is built, akin to the annual variation in the azimuthal error of the transit instrument. While the instrument has been in use the temperature has been increasing. Observations in the second half of the year may clear up this point.

It must not, however, be overlooked that one possible cause for this creeping may be found in the seasonal shift in the direction of the north-south barometrical gradient, accompanied by a seasonal change in the mean sea-level. In summer time the region of high barometrical pressure lies to the north of Great Britain, whilst in winter it lies considerably to the south.

The amplitudes on the diagrams seem sufficiently large to warrant an attempt to determine the tidal constants by means of harmonic analysis in the same way that the records of a tidal gauge are used. It may be said here that it was hoped originally to determine from the residuals between the computed and observed curves the direct effect of the moon's tide-generating force. At the present moment such an inquiry is no doubt rendered difficult owing to the slow creeping of the pendulum towards the north. The problem resembles that of trying to find the height of the tides from readings on a scale that is continually sinking into the ground, and at a rate which cannot be determined and which may not be uniform. There are also other practical difficulties connected with the winding of the clock, attending to the illumination, &c. It is by no means certain that after a disturbance the boom returns to the position originally occupied with no greater error than the small quantity sought. The discussion of the results, so far as they have gone, is useful as emphasising these difficulties, and with that view they are printed here. The observations from April 14 to April 28 seemed as free from objection as any that have been made, and as a first attempt it was arranged to derive the several tides in the manner described by Professor Sir G. H. Darwin. Clearly, if the main tides could not be recognised, it was hopeless to look for more recondite effects. There is a slight want of definiteness in the edge of the photograph; but this defect has been to some extent removed, it is hoped, by measuring both sides and using the mean. The curve was read off to a tenth of a millimetre, and that unit has been used throughout.

The results of the harmonic analysis are given in the following table. About these Sir George Darwin writes as follows: 'Since the oscillations of the pendulum are due to the weight of sea-water, it seems best to compare them with the tidal constants, as derived from ten years of observation at Hilbre Island.[1] This place being near the mouth of the Dee, seems to afford a better means of comparison than does Liverpool. The constants for Liverpool, however, differ but slightly from those at Hilbre Island. It is further desirable to compare the results with those derived from the equilibrium theory of tides for a place in lat. 53° 24′, approximately that of Bidston. I gave in Table E of the Report on Tides to the British Association for 1883 (' Scientific Papers,' vol. i., p. 25) a theoretical scale of importance of the several tides expressed in terms of the principal lunar semidiurnal tide M_2 as unity. But this table takes no account of the latitude of the place of observation, merely giving the relative importance of the several "coefficients.' What we require is to know what would be the deflections of the pendulum at Bidston if it were erected on an absolutely unyielding soil, and were only affected by the tide-generating forces due to moon and sun. The values given in that table for the semidiurnal tides may be quoted directly therefrom, and give the results in terms of M_2 as unity. But to reduce the diurnal tides to the same measure for this latitude, we must multiply the tabular values by $\sin 2\lambda \sec^2\lambda$, where λ is latitude. In this way we obtain a scale of relative importance for the lunisolar tide-generating force at Bidston.

	$\frac{1}{10}$ mm.	Hilbre Island	Tide-generating force at Bidston
Lunar semidiurnal M_2 .	$H = 17{\cdot}52$	9·758 ft.	1·000
	$\kappa = 318°$	319°	0°
Solar semidiurnal S_2 .	$H = 7{\cdot}45$	3·128 ft.	0·465
	$\kappa = 327°$	3°	0°
Lunisolar semidiurnal K_2 .	$H = 2{\cdot}03$	0·890 ft.	0·127
	$\kappa = 327°$	358°	0°
Lunisolar diurnal K_1 .	$H = 5{\cdot}64$	0·391	1·572
	$\kappa = 346°$	188°	0°
Solar diurnal P . .	$H = 1{\cdot}88$	0·146	0·520
	$\kappa = 346°$	174°	0°
Lunar diurnal O . .	$H = 1{\cdot}86$	0·370	1·118
	$\kappa = 237°$	41°	0°

Since the series of observations only extended over a fortnight, it was necessary to *assume* that the phase of K_2 was the same as that of S_2, and the amplitude about $\frac{3}{11}$ths. Similarly the phase of P is assumed to be identical with that of K_1, and the amplitude one-third. Hence in

[1] See Baird and Darwin, *Proc. Roy. Soc.* vol. xxxix. (1885), p. 196, col. 33.

the case of the pendulum there are really only four independent evaluations, and the values of K_2 and of P might have been omitted as far as concerns the provision of a means of comparison between the pendulum and the tide.

'A fortnight is much too short a period of observation to afford trustworthy values for the deflections of the pendulum, and therefore we should not place implicit reliance on the exact numerical values obtained.

'The phase of M_2 for the pendulum is virtually identical with that of the tide, but this exactness of coincidenie is probably to some extent accidental. The high tide, so to say, for the solar tide S_2, differs in phase from that of the water by 36° or 1h. 12m., and the amplitude is considerably greater relatively to M_2 than is the corresponding ratio for the sea.

'The phases of the diurnal sea-tides at Hilbre Island are very abnormal, for whereas it might have been expected that they should all come out nearly the same, the phases of K_1 and O differ by 147°. The result is, however, derived from so many years of observation that it is certainly correct and is, moreover, confirmed by the tidal constants for Liverpool. In the case of the pendulum we observe a similar abnormality, for the phases of K_1 and O differ by 109°. It is, however, remarkable that these tides are almost inverted with reference to the sea-tides. One may conjecture that there are perhaps nodal lines for these tides at some short distance out to sea, and that the bulk of the sea which produces the flexure is in the opposite phase from that which gives the visible tide at Hilbre Island and Liverpool. The amplitudes of K_1 and O are also very discordant, both in absolute amount and between themselves. In the sea K_1 and O have nearly the same amplitude, but with the pendulum that of K_1 is three times as great as that of O. This would result if the supposed node of K_1 were nearer the shore than that for O, because if this were so there would be a larger weight of water, oscillating in a phase opposite to that of the sea in shore, to produce flexure in the case of K_1 than in that of O. However, the series is much too short to justify any confidence in such conjectures.

'The last column gives the relative importance of the tide-generating forces for the several tides, and it will be seen that the force for K_1 is much larger and that for O somewhat larger than that for M_2. We see that both in the sea and in the case of the pendulum there is an enormous reduction of amplitude for diurnal tides as compared with the semidiurnal ones, but the reduction is markedly less for the pendulum. If these values should be confirmed, we may perhaps suspect that the direct lunisolar tide-generating force is rendering itself evident in the K_1 tide, and such a conjecture would accord with the phase of K_1 approaching 360° without the intervention of the nodal line at sea suggested above. However, as already pointed out, it is too soon to draw any conclusions with confidence.'

Whatever may have yet to come from this new departure in observations bearing upon Earth Physics, the work already accomplished is suggestive of certain conclusions.

We see that an observatory near to a shore line, in consequence of the diurnal tilting to which it may be subjected, is unsuitable for certain investigations. This, however, was pointed out by Sir George Darwin in his Report to the British Association in 1882. The discussion suggests precautions in the determination of the nadir at an observatory on the sea-coast, and probably the deepest mine in central Britain is still unsuitable as a place in which to measure the effects of lunar gravitation.

The deflections accompanying tidal loads observed at Bidston indicate a relationship between the yielding of areas represented by rocks and other materials and loads which are fairly well measureable.

These deflections which accompany a 10-foot tide amount at Bidston to approximately 0″·2. This yielding may be truly elastic, or it may possibly be partly due to the sagging of a surface like that of a raft under the influence of load. This latter idea falls in line with seismological observations, which show day after day that the large waves of earthquakes, whether passing beneath the alluvial plains of Siberia or beneath the crystalline rocks of North America, do so at a uniform speed. Seismology suggests that we live on a congealed surface, which, whether it is thick or thin, light or dense, apparently responds in a uniform manner to undulations which pass beneath it.

VII. *Megaseismic Activity and Rest.*

From historical records it has been shown that there are reasons for supposing that when there has been marked seismic activity in one portion of the world there has been a corresponding activity in some other part (see this Report, Section VIII., and also British Association Report, 1909, pp. 56-58). Although the records on which this conclusion is based only refer to disturbances which have affected land areas and seaboards, it suggests that periods of marked seismic activity are governed by general conditions. We now possess a second register, collected by stations which have co-operated with British Association stations during the last eleven years, which refer to reliefs in seismic strain in all portions of the globe. These I have divided into two classes. First, those which have only been recorded in a single hemisphere; and, second, those which have been recorded in the whole world. To the latter, which crossed an equator, I have given an intensity twice that of those which only disturbed instruments in a hemisphere. Earthquakes which have only been recorded throughout a single continent, no matter how much damage they may have caused, have been omitted. When these two classes are taken *en bloc* and arranged chronologically, it is at once seen that they have occurred in groups, and to each of these groups a value can be given dependent upon the number of shocks it contains and their relative intensities. From centre to centre of each group there are intervals, which usually vary between 10 and 30 days. An interval of 20 days is common, but it rarely reaches 40 days. On the accompanying diagram (see fig. 2) I have plotted the average intensities or values of groups which have been followed by 8, 9, 10, to 34 days of rest. For example, groups with an average intensity of 4·5 were followed by 10 days of rest, whilst groups with intensities of 5·4 have a rest period of 20 days. The mean line through these various determinations indicates that activity and rest are directly proportional. After marked efforts to bring about adjustments in the crust of our earth there are long periods of quiescence and *vice versa*. A definite time-interval is required to bring about a condition for hypogenic activity.

VIII. *A Catalogue of Large Earthquakes.*

In the British Association Report for 1908 I drew attention to the fact that existing catalogues of earthquakes consisted of materials extremely heterogeneous in their character. Earthquakes which had only shaken a few square miles were included with those which might have shaken the whole world. Further than this the heterogeneity varied

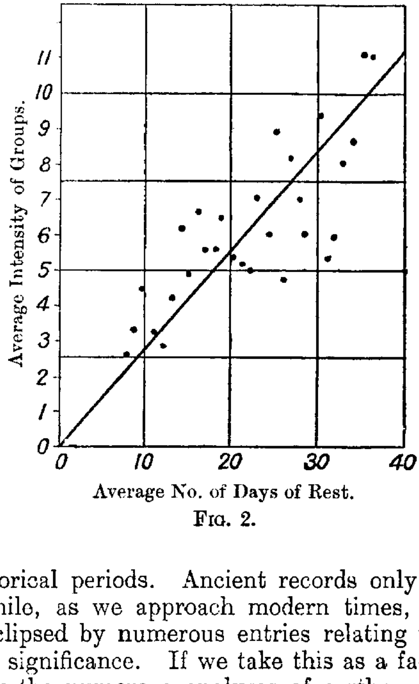


FIG. 2.

in different historical periods. Ancient records only referred to large earthquakes, while, as we approach modern times, this type of disturbance was eclipsed by numerous entries relating to tremors which had only a local significance. If we take this as a fact we see in it an explanation why the numerous analyses of earthquake statistics have failed to reveal any striking results respecting the distribution of earthquakes either in regard to space or time.

To obtain materials which might throw light upon seismic frequency and periodicity, it would be necessary to draw up lists for districts and one for the world from which seismic trivialities were so far as possible excluded. With this object in view, I have made certain progress with a catalogue which only refers to earthquakes which have been accompanied by destruction, or by changes of the earth's surface, or which have extended over large areas. In many instances these disturbances have resulted in adjustments in the earth's crust of geological importance. Taken in groups they indicate marked periods in the relief of seismic strain.

As an incentive to continue this new type of register, although in 1908 but a small portion of it had been completed, I called attention to the fact that it showed:—

First, that about 1650 there had been a period of marked seismic and volcanic activity in the world.

Second, that although the periods of seismic activity in Italy and Japan were each separated by irregular intervals of time, the years in which there had been marked activity in one of these countries closely corresponded with the years when there had been marked activity in the other. Should further analyses confirm this conclusion, the suggestion is that the relief of seismic strain in one part of the world brings about relief in some other part, or that relief is governed by some general internal or external agency.

The first entry in the catalogue is A.D. 1, and they are continued to A.D. 1900. This portion of the catalogue, which I propose to issue as Part I., will contain about four thousand entries.

I recognise its incompleteness, and trust that the *lacunæ* will shortly be filled up and brought together as a supplement.

When examining this catalogue it must be remembered that it only refers to disturbances which have originated on land surfaces and along seaboards. Further, it must be borne in mind that the historical records of different countries extend over very different periods of time.

The sources from which materials have been drawn are briefly as follow:—

Well-known catalogues like those of Mallet, Perry, and Fuchs have formed a foundation. Next came Japanese catalogues of earthquakes, together with abstracts from records published in China; in these much information is given not obtainable elsewhere. The translations of the latter made by Mr. S. Hirota and Professor E. H. Parker were particularly difficult. In the former of these (see Report 1908) certain slight errors have been found in the materials from which the translations were made. For dates between A.D. 46 and A.D. 194 one or two days should be added, while for dates between A.D. 200 and A.D. 1590 three to ten days should be subtracted. The resulting dates are for the most part those on which earthquakes were notified, and not necessarily those on which they occurred. Numerous lists and monographs on the earthquakes of particular countries have been translated. Three of these accompany this Report. Many documents were obtained from various parts of the world where Great Britain is represented, by the kind co-operation of the Foreign, Colonial, and India Offices. Much time was spent, but, I regret to say, not very profitably, in examining the files of our more important newspapers and periodicals. Better results came from foreign journals and the publications of learned societies. These and other references to sources of information will be detailed in the catalogue.

IX. *Catalogue of Destructive Earthquakes in the Russian Empire.* By MUSHKETOFF and ORLOFF.[1]

Abstracted by Mr. W. A. TAYLOR.

In the original catalogue we find 2,574 entries. From these the following have been abstracted as representing earthquakes of sufficient intensity to have caused destruction.

In many instances the dates for earthquakes which occurred in Chinese territory do not agree with those given by Omori, Hirota, and Parker. An alternative date is marked O. For registers prepared by these three writers see vol. xxix. of the Reports of the Imperial Earthquake Investigation Committee of Japan in Chinese idiographs. Reports of the British Association, 1908, p. 82, and 1909, p. 62. For Chinese lists we have also the 'Catalogue Général des Tremblements de Terre,' &c., presented to the Académie des Sciences by Ed. Biot in 1839, and the recent work by the late Le R. P. Pierre Hoang (see 'Variétés Sinologiques,' No. 28, published by the Mission Catholique, Shanghai, 1909). Dates from the latter are marked H. In many instances the Chinese dates may not refer to the time of an earthquake, but to the time at which it was notified in Pekin or some other city.

I = Earthquakes which have produced slight damage.

II = Earthquakes which have destroyed a few buildings.

III = Earthquakes accompanied by widespread destruction.

W.B. refers to dates according to the tables of W. Bramsen, 'Trans. Asiatic Society of Japan,' vol. xxxvii. Names of Provinces are in parentheses. Places of greatest destruction are in italics.

A.D.		
341		Armenia. I
715		Isnik-Membeji in Armenia, Constantinople. III
775		Mozan and Daralagoz, Siyunik Prov. III
803		Khogot Mountains. II
869		Town of Dvin (Tovin) ? III
893		Town of Dvin. III
894		Environs of Erivan. III
989		Greece, Thrace, Byzantine Province, Constantinople. II
995		Armenia, Towns of *Chapajar, Alhakh and Amit.* III
1000	Mar. 29.	Throughout the known world. III
1045		*Erzingan,* Ami and Ekeghiaz Prov. III
1091		Edessa and *Antioch.* III
1111		Van in Armenia. II
1114	Mar. 12.	Samosata, Ghizn-Mansur, Khesun, Marash, Kaben and Sis. III
1124		Khorassan. III
1131		Ani in Armenia. II
1139		Ganja (Elisavetpol), Kapassi-dagh. III
1143	April	Tangut country in Tibet. II
1156 for 14 months.	Oct. 26.	Syria, between Aleppo and Malatieh. III
1168		Erzingan. III
1170		Kief. III

[1] *Memoirs of the Imperial Russian Geographical Society,* vol. xxvi., St. Petersburg, 1893.

A.D.		
1196	May 3 or 4.	(1198 according to Likosten and Frigius). Poland, the *Erzgebirge* and the greater part of Germany. II
1219	Jan. 11.	Mshkavank in Armenia. I
1230	May 3.	Vladimir, Kief, Pereyaslavl, Novgorod and environs of Rostof, Suzdal and Vladimir. I
1268		Erzingan. III
1283		Mtsket in Caucasus, II
1287	May.	Erzingan. II
1308		Karabagh in Caucasus. II
1319		Ararat Prov. and Ani in Armenia. III
1348	Jan. 25.	Hungary, Tyrol, S. Italy, *Rome, Venice, Bâle,* Carinthia, Poland and Germany. I
1363		Mush in Armenia. II
1374	Dec. 8.	Erzingan. II
1378	April 10.	Ninghsia, Shanhan (Kansu), China. II (Hoang, April 30)
1440	Oct. 26.	Fortress Chuanglang in Lan-chou-fu, Shanhan (Kansu). II (Omori has Liang. There is a Lanchou-fu and a Lianchou in Kansu). (Chuanglang T. of Liangchoufu).
1443	June 5.	Bohemia, Silesia, Poland, *Hungary*. I
1458		Erzingan. III
1467	June 9.	Hsuanhua-fu (Chi-li), Tatung-fu (Shansi), especially *Peiyuan and Shochou.* (W.B. June 27.)
1474	Oct. 27.	Hoching (Yunnan). II
1474	Dec. 11.	Lingchou (Shansi). II (Omori has an earthquake on November 24 and December 11 at Lingchou in Ninghsia-fu) (Kansu).
1477	Mar. 19.	Ling-tao in Kungchang-fu, Shanhan (Kansu). II
1477	May 13.	Liang-chou-fu, Yulin-fu, Kan-chou-fu and Ninghsia-fu in Shanhan (Kansu), Yichou-fu (Shantung). II
1478	Aug.	Fort. Yangching (Sze-chuan). II (O. Chentu).
1481	Mar. 10.	Nanking, Fengyang-fu, Huaian-fu, Yangchou-fu, Hochiu in Chang-nan (*sic* Kiangsu and Anhui ?), Yangchou-fu in Shantung and in Honan. I
1482		Erzingan. III
1485	May 26.	Tsunhuachou Shintian-fu (Chi-li). II
1488	Sept. 28.	Hanchou and Mouchou in *Huangtai* (Sze-chuan). II
1494	Mar. 24.	Chuching-fu (Yunnan). (Hoang, September 16.) III
1495	April 10.	Ninghsia-fu in Shanhan (Kansu). III
1497		Chenting-fu (Chi-li), Ninghsia-fu, Yulin-fu, Chenfan-hsien, Linchou in Shanhan (Kansu), Taiyuan-fu, *Tungmo* (Shansi). I
1501	Jan. 19 to Feb. 4.	Repeated shocks in various parts of Shanhan (Kansu and Shensi), (Honan) and (Shansi). *Chaoyi-hsien* (Shensi). II
1501	Mar. 5 to April 2.	Puchou-fu (Shansi). I
1502	Oct. 17.	Nanking, Hsuchou-fu in Chang-nan (Kiang-su), Taming-fu, Shunte-fu (Chi-li), Chinan-fu, Tunchang-fu, Yenchou-fu, *Puchou* (Shantung). III
1505	July 10.	Ninghsia-fu in Shanhan (Kansu). II
1505	Oct. 16.	Nanking, Puchou-fu, *Anyi and Wanchuan* (Shansi). II (O. October 9, 10 and 16.)
1506	April 26 and 27.	Yunnan-fu and *Mumihuan* (Yunnan). II
1506	Aug. 28.	Fortress Aoshanwei, Laichou-fu (Shantung). II
1507	Nov. 4 to 6.	Yunnan-fu, Anchou, Hsinhsingchou (Yunnan). II
1511	Nov. 17.	Tali-fu (Yunnan), *Hoching and Chienchuan.* II
1512	Oct. 7 and 8.	Fortress Tengchungwei (Yunnan). II
1515	June 17 to July 17.	Fortress Yungningwei (Yunnan). III
1517	July 12.	Hsinhsing-chou, Tunghai, Hosi, Hsio (Yunnan). III

A.D.		
1520	Aug. 18.	Fortress Chingtuwei (Yunnan). II
1523	Jan.	Fenyang-fu in Changnan (Kiangsu), (Shantung), (Honan) and Shanhan (Kansu). I
1523	Aug. 14.	Fortress Tinghaiwei (Chekiang). II
1526	May 21.	Tengchung (Yunnan), Annanwei (Kweichou). I
1555	Jan. 23.	(Shansi), Shanhan (Kansu) and (Honan), *Huachou, Weinan-hsien, Chao-i-hsien, Sanyuan-hsien* and *Puchou-fu* (Shansi). (Hoang, 1556, January 23.) III
1556	April 1.	(Shansi). III
1558	Nov. 24.	Huachou (Shansi). II
1561	Feb. 21.	Fortress Shantanwei (Kansu). II
1561	June 5.	Taiyuan-fu, Tatung-fu (Shansi), Yulin-fu, *Ninghsia-fu, Kuyuan* in Shanhan (Shensi and Kansu). (Hoang. August 4.) III
1562		Ninghsia-fu in Shanhan (Kansu). II
1568	April 1.	Chingyang-fu, Huan-fu, Hangchung-fu, Ninghsia-fu in Shanhan (Kansu and Shensi), Anyi and Puchou-fu (Shansi), Yunyang in Huhuan (Hupeh) and (Honan). I
1568	May 2.	Fenghsiang-fu, Hsian-fu, Pingling-fu and Chingyang-fu in Shanhan (Shensi and Kansu). II
1574	Mar. 10.	Changting (Fou-kien). II
1577	Mar 12 and 17.	Tengyuehting (Yunnan). III
1580	Sept. 5.	Chingfing-lu (Chi-li). II
1584	June 17.	Erzingan. III
1590	June 27.	Lingtao (Kansu). (O. July 7.) II
1591	Nov. 11.	Shantanwei (Chi-li). II
1596		Nizhni-Novgorod. III
1598		Amasia and Chorum. III
1603	May 20.	Chunghsien-hsien in Chentiang-fu (present Anlu-fu in Hupeh). (O. and H. May 30.) II
1604	Oct. 15.	Kungchang-fu and Litsuan-hsien in Shanhan (Kansu). (O. and H. October 25.) II
1605	July 3.	Luchuan (Kwangsi). (O. July 14.) II
1609	July 2.	(Kansu), especially *Kunei and Tsingshui*. (O. July 13.) III
1612	May 24.	Tali-fu and Chuching-fu and Wuting (Yunnan). (O. July 2, H. June 3.) III
1615	Feb. 19.	Yanchou-fu in Changnan (Kiangsu). (O. March 1.) II
1620	Feb. 24.	In Yunnan, Chaoching-fu, Huichou-fu (Kwantung), Chingchou-fu, Chengtan-fu (Hupei). (O. March 5.) I
1622	Mar. 8.	Chinan-fu and Tungchang-fu (Shantung). (O. March 18.) III
1622	Oct. 15.	Pingliang-hsien and Lungte-hsien (Kansu). (O. October 25). III
1624	July 7.	Paoting-fu (Chi-li). (O. July 20.) II
1626	June 18.	Pekin, Chinan-fu, Tungchang-fu (Shantung), Honan-fu (Honan), Tiantsin-fu, Hsuanhua-fu (Chi-li), Tatung-fu (Shansi). (O. June 28.) III
1627	Jan. 6.	Ninghsia-fu in Shanhan (Kansu). II
1627	Feb. 6 to Mar. 8.	Ninghsia-fu. III
1631	July 11.	Lingtao-fu and Kungchang in Shanhan (Kansu). (O. July 22.) III
1641	Feb. 5.	Tabriz in Persia, and environs. III
1648	April 2.	Town of Van, Armenia. III
1667		Shemakha in Caucasus. III
1669	Jan.	Shemakha and Lacha, Caucasus. III (Perhaps the same as 1667.)
1670		Shemakha. II
1670	Dec. 22 and 23.	Shemakha. III
1670	Jan. 22.	Shemakha. II
1671	Aug. 8.	Shemakha. II
1679	June 4 to 12.	Erivan and neighbourhood as far as Ararat. (v. Hoff, 1680.) III

A.D.		
1680		Various parts of Europe and Asia, especially Italy and Poland. I
1700	June or July	Nerchinsk in Siberia. I
1716		Dzungaria, Baikal and Zaisan, *Aksu* on southern flank of Tian-shan. III
1718	June 8.	Singansan or Sinsusu (cap. of Shansi?) and in Tongwei and Tin-miuchin (Si-ngan, cap. of Shensi?) (June 10, Chinan, in Chanchou, Tungwei, Kungchang-fu (Kansu) H.) II
1719	July.	Northern China. III
1720	June 11.	Pekin. (O. West of Pekin.) II
1724	May 31.	Pekin and many parts of (Shansi). III
1725	Jan. 21.	Chita in Transbaikalia and west to R. Selunga. I
1731	Nov. 19.	Pekin and neighbourhood. III
1737	Oct. 6.	Around Avacha in Kamchatka and Kuriles. III N.E. 4° × 1°.5.
1737	Sept. 23 and Oct. 23.	(Perhaps identical with preceding). Nizhne-Kamchatka fort. II
1737	Dec. 6.	Kamchatka and the Kuriles. II
1742	Feb. 7.	Bering Island. II
1742	June 16.	Irkutsk. I
1742	June 16.	Bering Island. III
1755	Nov. 1.	The Lisbon Earthquake. III
1756		Kamchatka. III
1758	Dec. 7.	Russian Lapland, Kola town. II
1761	Dec. 9.	Kolyvan factory and Ubinskaya fort and Chagirskaya fort, W. Siberia. I
1766		Province Pasin (Bassen) Armenia. II
1769	Oct. 24.	Irkutsk and Selenginsk. I
1772	Feb. 18.	Town of Kola, Russian Lapland. I
1772	Dec. 5.	Irkutsk, Selenginsk and Kiakhta. I
1776	Dec. 9.	Barguzin fort, Transbaikalia. I
1779	Aug. 1.	Irkutsk, Balagansk, Selenginsk. I
1783		The Calabrian Earthquake, shocks felt this year also in parts of Asia, especially the Altai.
1784	early in August	*Erivan*, Armenia extending to Erzerum, *Mush and Gyeghi*. III
1786	Feb. 27.	Upper Silesia, Bohemia, Hungary and Poland. I
1788	July 22.	Aleutian Islands in Unga. III
1788	in Spring.	Prov. of Balu (Palu?). III
1790	April 6.	S. Russia, Galicia, Transylvania, the Bannat and Rumania, and felt as far as Constantinople. III
1791	April 15.	Nizhne-Kamchatsk. II
1792	Aug. 23.	Petropavlovsk, Nizhne-Kamchatsk, Paratunka and all east coast of Kamchatka. II. N.N.E. 4° × 1°.
1798	May 23.	Perm, Kungur and villages of Perm, Kungur, Oca and Verkhoturye districts. I
1802	Oct. 26.	From Ithaca and Constantinople to St. Petersburg and Moscow, especially in *Wallachia*, *Moldavia* and the south of *Transylvania*. III
1802		Aleutian Islands. II
1803	Jan. 8.	Belostok, Grodno Government. I
1803	Oct. 29.	Tiflis. I
1804	Oct. 11.	Tiflis. I
1806	April 22.	Irkutsk. I
1806	Aug. 8.	Krasnoyarsk. III
1809	Mar. 10.	Viatka and district. I
1814	Sept. 3.	Irkutsk, *Tunkinsk* fort and surrounding villages. III
1814	Dec. 17.	Irkutsk and felt as far as Troitskosavsk, 345 miles distant. I
1817	April.	Chang-li (Sze-chuan). III
1819	Jan. 29.	Tiflis. I
1820	Mar. 7.	Irkutsk and around the *Turansk* frontier post. I
1821	Nov. 17.	Almost all the south of Russia, especially in *Jassy* in Rumania, Dubossari, Nikolaief, Olviopol, Ochakof. I

A.D.		
1827	May.	Kirensk in Irkutsk Government and in Petropavlovsk village, 53 miles from Kirensk. I
1827	Oct. 21 to 23.	Tiflis and Stavropol, Caucasus. I
1827	Nov. 16.	Santa Fé de Bogota followed by earthquake in Okhotsk on the 17th. I
1827	June.	Commander Islands. III
1828	Aug. 7 to 14.	*Old Shemakha*, Shusha and many villages in the Caucasus. III
1828	Mar. 7 to 19.	Irkutsk, Troitskosavsk, Kiakhta, Turansk frontier post. III
1829	Nov. 26.	Bukharest in Wallachia (Centre), *Wallachia, Moldavia and Bessarabia*, and felt over all S.W. Russia, Galizia, Bukovina and Transylvania. III
1829	Nov. 31.	Barnaul and Suzun smelting-works. I
1830	Mar. 9.	*Tiflis, Georgief* district, Kizlar, Mozduk, Ekaterinodar, *Andreief village, Tarka.* III
1830	June 25.	Vnezapnaya, Caucasus. II
1830	June 26 and 27.	Huaiching-fu (Honan) and parts of (Chi-li), south of Pekin. (H. June 12–13.) III
1830	Dec. 4.	*Anapa* and Taman Peninsula. I
1830	Dec. 26.	230 miles from Pekin, perhaps identical with June 26. III
1831	May 19.	Turkinsk mineral springs, near Lake Baikal. I
1832	Jan. 22.	Bokhara, Kokand, Badakshan and Upper Oxus. III
1834	Feb.	Anapa, Bugaz and shore of Abkhasia. I
1834	July 10 to 22.	Changte-fu (Honan), especially in the district of Wungang, westwards to (Shansi), northwards to (Chi-li) and east to (Shantung). (O. June 28–July 19.) III
1835	April 21.	Bessarabia and Bukharest. I
1835	July 20.	Lemberg. I
1835	April 14.	Pribylof Islands. III
1838	Jan. 23.	S.W. Russia, Wallachia, Moldavia, Transylvania, Hungary and Balkan Peninsula. III
1839	June 28 and 29.	Village Fedorovka, Saratof Government. II
1839	Aug. 18.	Irkutsk and along the Selenga R. III
1840	July 2.	In the departments of Surmala, *Sharur* and *Nakhichevan* in the Talyshef Khanate and the Ordubat district. III
1840	July 6–8.	Ararat, Sharur and Nakhichevan districts. III
1840	July 27.	Ararat and Sharur. III
1840	Dec. 7.	Sharur and Nakhichevan. II
1841	May 18.	Village Kevragh, also in Nakhichevan. II
1841	May 18.	Petropavlovsk and Ostrovnoe. II
1841	Sept. 22.	Nakhichevan and neighbourhood. I
1841	Dec. 25.	Anapa, Nikolaievak and Vitaz. I
1842	Jan. 2.	Baku and neighbouring villages. III
1843	Oct. 2.	Bessarabia, Baltain Podolia, Soroki in Bessarabia and Odessa. I
1845	May 24.	Akhaltsyk and district. II
1846	Jan. 11.	Nakhichevan. I
1846	April 23.	Javarisi, Kutais Government. II
1846	Aug. 18.	*Irkutsk* and Kirensk. I
1847	May 15 or 16.	Kushva, Verkhnaturye, Nizhneturye and Bisert mines and works in the Urals. I
1848	Sept. 22 to 25.	Shemakha. I
1849	Jan. 29.	Ishim in Tobolsk Government. I
1851	April 13.	Nakhichevan district in Erivan Government. I
1851	Nov. 28.	Okhotsk Dept. along coast of the sea of Okhotsk from the Taui to the Tuman post, 470 miles. II N.E. $3^\circ \times 1^\circ.5$.
1852	June.	(Kansu), China. III
1852	July 24.	Erzerum. III

A.D.		
1853	Jan. 18.	Demijan monastery and village of Chubukhly, Tiflis district and Sevanga Island. II
1853	April 14.	Shanghai; village 30 miles from Shanghai completely ruined. II
1856	July 11.	Shemakha. III
1856	Aug. 14 to 17.	Southern part of (Chi-li), China; *Yuching*, 20 miles from Pekin destroyed. III
1857	Dec. 24.	Semipalatinsk Province and Tomsk Government, especially Kokpektinsk and Ust-Kamennogorsk. I
1859	June 2.	Erzerum and neighbourhood, especially in the mountains Palenjukan and Yarlydagh III
1859	June 12 and 13.	Shemakha. III
1859	June 26.	Shemakha and Erzerum. I
1859	July 13.	Tiflis and Erzerum. I
1860	Nov. 4.	Belii Kliuch, Caucasus. I
1861	Feb. 16.	Sunday Islands. II
1861	Feb. 22.	Copper Island, Bering Sea. I
1861	Mar. 5.	Shemakha. I
1861	Dec. 17.	Alkan-zhurt? and Samasha stations in the Caucasus. I
1862	Jan. 12 to 31.	Irkutsk, Selenginsk, Verkneudinsk, Chita, Petrovsk, Nikolaievsk, Upper and Lower Angora Districts. E.S.E. 9°.5 × 7°. II
1862	April 28.	Selenginsk. I
1862	Dec. 19.	Lenkoran, Shemakha and Shusha. I
1862	Nov. 29.	Shemakha. I
1864	Jan. 3.	Environs of Ardebela, Persia. Also felt at Lenkoran, Karabagh and Shirvan. III
1864	Jan.	Hankow, China. III
1865	Mar. 22.	Merke in Turkestan Province. I
1865	May 22.	Selenginsk, Irkutsk, Verkhneudinsk. I
1865	May 27.	Poretskoe, Simbir Government. II
1865	Sept.	Around the Taishan Mountain (in Shan-Tung), China. III
1866	Mar. 8.	Verkneudinsk and Irkutsk. I
1866	Aug. 25 or Sept. 6.	Petropavlovsk and Lyersny. I. II
1866	Nov. 4.	Soroki, Bessarabia. I
1867	May 5.	Pekin. I
1867	May 7 and 8.	Selenginsk. I
1867	July 23.	Telaf, Shemakha, Mukhravan, Zurnabad and Elizavetpol. I
1868	Feb. 4.	Tashkent. II
1868	Feb. 18.	Akhalkalaki, Kvirila, Toporovan, I., and Ardahan in Kars Province. I
1868	Feb. 25.	Erzerum, Alexandropol, Akhalkalaki. II
1868	Mar. 18.	Telaf, Delizhan, Shusha, Jebrail, Zakatali, Shemakha, Belasuvar, Chatakh. I
1868	Mar. 21.	Grozny and *Gorachevodsk* station. I
1868	April 4.	Tashkent. II
1868	April 11.	Kars and Nizhni-Pasin, Erzerum, Tiflis. II
1868	June 30.	Tsogonoi village, Tersk Province. II
1869	Dec. 10.	Khojent. I
1869	Sept. 2.	Shemakha and the Kuban district over 2,200 square miles. Most violent in Sundi, 12 miles from Shemakha. III
1869	Nov. 1.	Valley of the Barguzin river, Lake Baikal. I
1869	Dec. 26.	Tiflis, Alexandropol, especially villages Malye, Jamzhili and Janshtan. III
1870	April 11 to 21.	Batang (Sze-chuan), China. III
1870	July 7 and 8.	Eastern shore of Black Sea. I
1871	Mar. 4.	Irkutsk Government and Transbaikal Province and North Mongolia. I

A.D		
1871	Dec. 11.	Gulija, 56 miles west of Erivan, and in the Echmiadzin district. II
1872	Jan. 28 to Feb. 19.	Shemakha and neighbourhood. III
1873	Oct. 15.	Monastery Kopenkovat, Uman District, Kief Government. II
1874	Aug. 24.	Nazran fortress, 16 miles from Vladikavkaz. I
1875	July 25.	Sebastopol and neighbourhood. I
1875	Aug. 7.	Shemakha and its district. III
1875	Aug. 17.	Grubesheva, Lemberg Government. I
1877	Aug. 8.	Oni and Utseri on River Rion. I
1878	Mar. 28.	Bakhti fort in Sergiopol district. I
1878	Mar. 31.	Gorachevodsk convict settlement in the Caucasus. II
1878	May 4.	Village Ullu-gatam in S. Daghestan. II
1878	July 16	Fort Kishan-aukh, Tersk Province and neighbourhood. I
1879	Jan. 8	Alaghir, Tersk Province. I
1879	Mar. 22.	Ardebela, villages on S. and S.W. foot of Savalan mountain, Armu-dagh and other places on road from Teheran to Tabriz. III
1879	June 29.	Dep. (Kuangsu), China. III
1879	Oct. 9.	Varenska, Gostagaievska, Troitzkaya and *Kurgan* stations in Trans-kuban Province. I
1879	Oct. 28.	S. Hungary and felt in Transylvania, Servia, Rumania and Bessarabia. III
1880	Oct. 22.	Shemakha. I
1880	Dec. 2.	*Verny*, extending to Kurumdof and Karakul. I
1880	Dec. 25.	*Odessa* and felt in Bessarabia and Rumania. I
1881	Jan. 31.	Petrovsk, Transbaikalia. I
1881	May 30.	Van, village of *Tegut* and environs. III
1882	July 19.	Temir-khan-Shura, Caucasus. I
1883	May 3.	Tabriz and most of Azerbaijan. I
1883	Nov. 3.	Karakoyunli, 30 miles from Erivan. II
1883	Nov. 14.	Tashkent and Osh in Fergana. I
1883	Nov. 18 to 24.	Sultanabad, 20 miles from Osh, and Osh. II
1884	Jan. 26.	Tali-fu (Yunnan). II
1884	Dec. 19.	Shusha. I
1885	Jan. 12.	Villages Kabansk and Barguzinsk, east of Lake Baikal. I
1885	Middle of May.	Village of Sikukh, N.W. of Derbent. II
1885	Middle of June.	Village Shishkina, 33 miles from Orenburg. II
1885	Aug. 3.	Sukuluk, Belovodsk and Karabalti and extending to Tashkent, to Verny and to Ili. III
1885	Oct. 9 to 25.	Tokmak district, Semreachie. I
1886	Jan. 4.	Chembar, Penza Government. I
1886	June 27.	Shemakha. I
1886	Nov. 8.	Tokmak and Verny. I
1886	Nov. 29.	Tashkent. II
1887	Jan. 14.	Semipalatinsk, Usk-Kamennogorsk, Altai district and Biisk district. I
1887	June 9 to 28.	Verny, Sophiisk, Kopal, Gabrilovka, Aksu, Karakul (Przhevalski), valley of the Ili. III
1887	July 16.	Batum, Ozurgeti and *Kutai*. I
1887	Sept. 9.	Russian Turkistan, Verny. II
1888	April.	In (Yunnan), especially the towns *Shipin*, *Chenshui* and *Peiyuang-ting*. III
1888	May 15.	Russia, Erivan. I
1888	Sept. 16.	Russian Turkistan, Verny and Pishek. I
1888	Sept. 22.	Ardahan, Okan, &c. II
1888	Sept. 23.	Transcaucasia, Batum. I
1888	Sept. 23 to 26.	Kars and other places in the Kars Province. II

A.D.		
1888	Nov. 28.	Tashkent, Khojent and places east of Tashkent.
1888	Nov. 29.	Verny and Kopal. I
1888	Dec. 3.	Verny. I

A List of Destructive Earthquakes in Iceland.[1]

Abstracted by C. A. Gosch, Esq., from 'Landskjálftar á Islandi,' by Thorvald Thoroddsen, Copenhagen, 1899-1905.

The work from which the following abstract has been made was issued by the Icelandic Literary Society in two parts, of which the first, pp. 1-200, was published in 1899; the second, pp. 201-266, in 1905.

The relative 'destructivity' is indicated by the numerals I, II, and III, see p. 57.

Earthquakes in Iceland appear to be closely connected with local volcanic activity, and it is therefore convenient to group them according to the volcanic areas in which they originate, as Mr. Thoroddsen has done. Occasionally, however, an earthquake extends from one area to another, so that by this arrangement the same seismic disturbance may have to be mentioned in more than one list. The principal earthquake area in Iceland is that of the Sudurland, the southern part of the island, and particularly the Sudurland underland,[2] which means the lowlands in that part of Iceland. This district lies between the central plateau and the south coast, and is bounded to the east by the mountains about the Myrdals jökull, near the southernmost point of the island; and to the west by a ridge, which on the western side slopes down to the Faxa Bay (Faxa flói or Faxa fjördr). It is an alluvial plain, which fills up a prehistoric bay of the sea, in which isolated rocks and mountains represent ancient islands. The extent is given by Mr. Thoroddsen as '70 sq. milur,' or about 1,300 English square miles. The principal seat of volcanic activity here is Hekla, at the north-east corner of the district. The localities mentioned in Mr. Thoroddsen's list of earthquakes in the Sudurland are situated partly in Arnessysla, partly in Rangarsysla; 'sysla' being the appellation for certain administrative divisions. Arnessysla is the westernmost, the furthest from Hekla, and comprises the following subdivisions frequently mentioned—viz., Ölfus, the westernmost, west of the river Ölfusá, next Flói between the sea and the lower courses of Ölfusá and Thjorsá; to the north of these, inland, are Grimsnes Thingvallasveit, Bishopstungur, Skeid, and, finally, reaching up to the edge of the highland ice, the so-called Hreppar—viz., Eystrihreppur or Gnupverjahreppur and Hrunamannahreppur or Ytrihreppur. The river Thjorsá divides

[1] A second abstract of this work has been received from the Hon. S Allan Johnstone, British Minister in Denmark. Although in both cases these registers represent the selection by independent workers of earthquakes which were destructive, the one confirms the other.

[2] In Mr. Thoroddsen's paper the names are mostly given in the Dative case, governed by á; but in this abstract they are treated as would be English names and not declined.

Arnessysla from Rangarsysla, which comprises the districts of Holt, Land or Landsveit, Rangarvellir—the northern extremities of the two latter embracing the foot of Hekla—further to the east Hvolhreppur and Fliótshlid; finally, on the sea coast, Landeyjar and Eyafjallasveit.

The earthquake area of the Faxaflói lies on the west coast of Iceland, and comprises the districts bordering on that bay with the peninsula which forms the south-west corner of the island, terminating in Reykjanes, near which, in the sea, is the principal seat of volcanic action here. In this area are Bórgarfjördr, Reykjavik and Krisuvik in Guldbringasysla, which borders on Ölfus in Arnessysla.

The earthquake area of the Nordurland or North Country, comprises the whole northern coast of Iceland from Hunaflói eastwards, and the centre of volcanic action here is the Myvatnsveit, the district round the lake of Myvatn, where a number of craters exist.

The north-west part of Iceland, which forms a peninsula connected with the main island by a narrow neck, is rarely visited by earthquakes, at least noteworthy ones, and the same is the case with the east coast. Nor are many earthquakes recorded from the central part of the island or from the vast icebound, volcanic complex of mountains called the Vatna Jökull, which fills up the south-east corner of Iceland. The absence of more numerous records may, however, be due to the desolate almost inaccessible character of the region.

A List of Destructive Earthquakes in the Sudurland.

A.D.

1013 'Great earthquakes.' No date or particular locality is indicated. II

1151 No direct mention of an earthquake, but only that houses were destroyed and people killed in connection with an eruption of a volcano in the interior, the Trölladyngjur, literally the habitations of the gnomes, a name applied to several mountains in Iceland. No particular locality or date is given. II

1157 Earthquake in connection with eruption of Hekla, January 19. II

1164 Earthquake in Grimsnes; no date given. II

1182 Earthquake; no date or locality indicated. II

1211 Great earthquake, July 7; the locality is not particularly indicated, but it is stated that on the day before there had been an eruption in the sea south of Reykjanes, resulting in the formation of some new 'Eldeyjar' or Fire Islands. A group of islands of that name is still in existence. II

1240 Great earthquake throughout the south country; eruption off Reykjanes. No date. I

1294 Great and widespread earthquake in Fliótshlid and Rangarvellir; connected with an eruption of Hekla. No date is given. III

1300 Several earthquakes about Christmas time through the south country, contemporaneously with an eruption of Hekla, which commenced July 10 and lasted nearly 12 months. II

1308 Great earthquake throughout the South Country. No date. II

1311 Earthquake in the night between January 10 and 11. No particular locality indicated, but it is stated that on January 25 there was an eruption in the Austurjökulls. I

1339 Severe earthquake throughout the South Country, May 22. It was felt mostly in Skeid, Flói and Holt. III

1370 Earthquake in the South Country about Ölfus. No date. II

1389-90 Earthquake in the South Country; no particular place or date mentioned. There were eruptions from Hekla, Trölladyugjar and Sidu Jökull. II

1391 A great earthquake throughout the South Country, particularly in Grimsnes, Ölfus, and Flói. III

1510 Earthquake at Skalholt, about 20 miles west of Hekla, in connection with an eruption of the volcano on July 26. I

A.D.
1546 Earthquake at the end of May, mostly in Ölfus. II

1552 Earthquake shocks at Candlemas eve (March 2); no locality mentioned. I

1554 Severe earthquakes which lasted through half a month, so that people had to live in tents. No particular locality mentioned, but it is stated that at the same time an eruption of Hekla was going on, which lasted six weeks. The date is given as between Crossmass (the Festival of the Invention of the Cross, May 3) and 'fardag,' which means the last four days of May. I

1578 Earthquake in Ölfus in the evening of All Saints' Day (November 1), supposed to be caused by an eruption of Hekla, which was going on during that autumn. II

1581 Great earthquake in the month of May (between Crossmass and fardag), particularly in Rangarvellir and Hvolhreppr. III

1584 'Great earthquake in Iceland, but it is not known in what part it happened; most probably, however, in the South Country.' II

1597 Several severe shocks of earthquake at Skalholt on January 3, in connection with an eruption of Hekla. In the same spring, after the eruption of Hekla, there was a destructive earthquake in Ölfus. II

1613 An earthquake in the South Country, particularly severe in Skeid. II

1619 Earthquakes after midsummer, also eruption of Hekla; no particular date or locality mentioned. I

1624 Continual earthquakes all through November, particularly in Flói. II

1630 Three earthquakes during the winter, one on February 21, throughout the South Country. Damage done at Skalholt, &c. II

1638 An earthquake in the South, did damage at Ölfus; no date given. II

1657 Great earthquakes in the South and in the West, mostly in Floi and in Fliótshlid, where damage was done, March 16. III

1671 Great earthquake in the summer in Grimsnes and Ölfus. III

1693 Strong earthquakes all over the Sudurlandunderland, which were also felt at sea, connected with an eruption of Hekla which commenced February 13. I

1706 In the course of the winter there were several earthquakes—viz., two in the evening of January 28, one in March, one on April 1, and the most severe on April 20 in the morning which wrought great destruction in Ölfus. It was also felt in Flói and even, though weaker, in the Faxaflói area. III

1724 Earthquakes in the month of August, mostly in Arnessysla. This disturbance reached Krïsuvik in the Faxaflói area and was felt strongly at Reykjanes Skaga. II

1725 Between April 1 and 2 there were terrible earthquakes in Arnes- and Rangarsysla. In the same morning fire burst out of the ground round Hekla. III

1726 Earthquakes late in the summer in Rangarvellir. In the winter there had been an eruption in the Eastern Jökulls. II

1732 Severe earthquake on Sept. 7 in Rangarvellir and Eystrihreppr; the people took to living in tents, as the shocks continued for nearly half a month. II

1734 On March 21 a severe earthquake occurred in Arnessysla, particularly in Flói.

1749 A severe earthquake in the Sudurland, particularly in Ölfus; it was felt also in Borgarjördr and elsewhere in the Faxaflói area. II

1752 Earthquakes occurred during the winter in Ölfus. II

1766 Many earthquakes in the country round Hekla during an eruption which commenced April 5. The shocks were felt particularly to the south-west of the volcano and were destructive in Arnessysla, particularly in Ölfus, on September 9 and 10. They spread west to the Faxaflói area (Reykjanes) and south to the Vestmanna Islands off the coast. Two to four shocks were generally experienced every twenty-four hours. III

1784 On August 14 and 16 there were severe earthquakes all over the Sudurland, 'the worst that had happened in Iceland since the land became inhabited.' They were strongest in Arnessysla and Rangarsysla, particularly the former, but were felt all over the south, and spread not only to the Faxaflói area (Snæfell), but even to Isafjördr in the extreme north-west of Iceland.

The Vestmanna islands also were severely shaken, and shocks were felt even in Skaptafellsysla, east of Rangarsysla towards the Vatna Jokvill. The seismic disturbance lasted till Christmas. III

A.D.

1789 Severe earthquakes all over the south-west country, principally in Arnessysla. They commenced on June 10, and for a week after there was hardly any quiet time night or day; there were scarcely ten minutes between the shocks, and some were felt afterwards during the summer. III

1797 Earthquake shocks occurred on September 19 in Hvolhreppr. I

1799 Earthquake shocks were noticed in the morning of March 31 and the following day in Fliótshlid and Landeyjar. I

1808 An earthquake worth mentioning occurred. No date or locality given. I

1810 A strong earthquake was noticed east of Hekla, and also southwards, October 21. I

1828 Severe earthquake in Fliótshlid and Landeyjar. No date given. II

1829 On February 21 and in the night following there were earthquakes all over Sudurland. I

1838 June 12 in the morning early a notable earthquake occurred at Eyrirbakki, in Flói, which was also felt in the Nordurland between Hunaflói and Skjalfandi; at least there was an earthquake there on the same day. II

In the south the shocks continued to June 17. II

1845–7 Weak earthquake shocks occurred in the country round Hekla during an eruption which lasted from September 2, 1845, to April 6, 1846. They reached almost 28 English miles south-west of the volcano, but only 9–14 miles north-east of the mountain. Shocks were noticed in various places in the district, especially from October 4 to 13, 1845, January 11 to 18, March 5 and April 4, 1846, After the eruption had ceased, shocks were observed in this district on April 18, May 3 and 8, June 5, November 26, 1846, and January 7, March 2 and 3, 1847. The shocks on May 3, 1845, were felt also in the Faxaflói area, at Krisuvik and Reykjavik, where shocks were felt also on May 4, August 31, 1846, and February 15, 1847. During the eruption some shocks were felt in the Nordurlandar, and sharp shocks were felt during April and May 1847 at Grimsey, an island north of Iceland, just under the Arctic circle. I

1868 Earthquakes in the Sudurland, November 1 and during the week following. This disturbance originated in the Faxaflói and is mentioned on the list for that area.

1878 Earthquakes, February 27, in the whole of the south-west of Iceland, particularly in Land, Rangarvellir, the Hreppar, Fliótshlid, and the Vestmanna islands, but were not felt in all places at the same hour. At the same time there was an eruption of flames, in the lava fields north of the Krakutind, to the north of Hekla. I

1887 October 28. Earthquake at Eyrarbakki in Flói, where the disturbance lasted 10 seconds, and the direction was from north-north-west to south-south-east; at Kirkjubæ in Rangarvellir, where the direction was from north-west to south-east; also in Fliótshlid, Landeyjar, and Holt. This earthquake extended to the Faxaflói area. II

1889 Earthquake shocks at Rangarvellir on April 19, the direction being from east-south-east, and at Eyrarbakki in Flói, April 30, where the first shock lasted three seconds, but the principal one, a full second, the direction being from east-south-east to west-north-west. I

1896 August 26 and 27, and again September 5 and 6, more or less severe earthquakes occurred in all parts of the Sudurland and on the Vestmanna islands. Several districts were shaken again on September 10. III

These earthquakes were felt at several distant localities such as Hornafjörd on the south-east coast, though not, as it appears, in the Skaptafellsysla, between the Sudurland underland and Hornafjörd. They were felt at Reykjavik (August 26 and 27 and September 5), Börgarfjördr and elsewhere in the Faxaflói area, and on the north-west coast of Iceland even at Isafjördr in the extreme north-west. III

1899 The extensive earthquake in the Nordurland after New Year was felt in the Sudurland, particularly at Eyrarbakki (Floi) on February 27. I

The disturbances on the Sudurland in 1887, 1889, and 1899 are not mentioned by Mr. Thoroddsen on his list of earthquakes there; but in the list of earthquakes in the Faxaflói.

A List of destructive earthquakes about the Faxaflói.

There are no old records of earthquakes in this area available.

A.D.

1663 Earthquake at Reykjanes Skaga. No date. I

1706 The great earthquake which devastated Arnessysla in the month of April would seem to have been felt, though faintly, near the Faxaflói, as it is mentioned in Mr. Thoroddsen's list of earthquakes in that district, but all the details mentioned by him there refer to localities in Arnessysla. I

1724 The earthquake in Arnessysla in August was felt at Reykjavik.

1754 Earthquake at Krisuvik. No date indicated. I

1825 January 18 and 21, shocks at Reykjavik. II

1860 September 20, earthquake shocks occurred at Reykjavik; the direction was south-west to north-east.

In the middle of June and between December 30 and 31 weaker shocks were noticed, having the same direction. I

1864 Earthquake in Reykjavik on February 16. I

1868 Frequent and strong shocks occurred in the beginning of November at Reykjavik and Börgarfjördr. They were also noticed in the Sudurland, November 1 to 7. II

1878 The earthquake in the Sudurland, February 27, was felt at Reykjavik; there were three shocks.

1879 Strong earthquakes at the end of May at Reykjanes Skaga and Krisuvik. At the same time there was an eruption in the sea off Reykjanes, near the Geirfuglaskeri, the last breeding-place of the Great Auk.

1887 The earthquake in the Sudurland, October 28, was felt at Reykjavik; there were two not very strong shocks. I

1889 October 13, strong shocks were felt at Reykjavik and other places round the Faxaflói. These were scarcely felt in the Sudurland, which had suffered from an earthquake earlier in the spring.

1896 The great earthquakes in the Sudurland in August and September were felt at Reykjavik, Börgarjördr and elsewhere round the Faxaflói. I

1899 The extensive seismic disturbance in the Nordurland after New Year was also felt round the Faxaflói, particularly at Reykjavik, February 27. I

Several earthquakes in the Sudurland at various times were felt about the Faxaflói, but were not destructive.

A List of destructive earthquakes in the Nordurland.

As regards this area, too, early records of earthquakes are almost absent.

1260 A great earthquake in the North, at Flatey, an island in the bay called Skjalfandi. No date. II

1618 Constant earthquakes continued night and day from harvest time to Christmas. Damage was done at Thingeyjarthing.

1724 Earthquake, May 17, in Myvatnsveit in connection with a series of volcanic eruptions in that district which lasted to 1730, during which time earthquakes were frequent.

1725 Earthquake in Myvatnsveit in connection with the first eruption of the volcano Leirhnukur, on January 11, and again April 19, in connection with the eruption of Bjarnaflaga.

1728 Several earthquakes occurred in the Myvatnsveit in connection with eruptions from four different craters in the district. The strongest was on April 18, but many minor shocks were noticed all through that year. I

1755 September 11 to 24, a series of earthquakes affected the north coast of Iceland along the shores of Skagafjördr, Eyjafjördr and Skjalfandi. Damage was done at Husavik and several minor places. The disturbance reached Grimsey Island to the north of Iceland, but there was no earthquake in Myoatvisveit nor in other parts of Iceland. Mr. Thoroddsen mentions that on October 17 commenced a violent eruption of the Katla in the Myrdals Jökull, south of Hekla, near the coast, and he reminds his readers that the famous earthquake at Lisbon occurred a fortnight later. III

A.D.

1838 In the night between June 11 and 12 an earthquake shook the north coast of Iceland, between Hunaflói and Skjalfandi, which was not felt strongly inland, but, like that of 1755, was very strong in the islands off the coast, Grimsey and Drangey. The movement came from the sea and travelled from the north-east to the west to the interior. This earthquake was felt in the Sudurland at Eyrarbakki, June 12. III

1867 December 31, in the early morning there was an earthquake along the north coast, particularly at Akureyri and Husavik, it reached to Vöpnafjördr, on the east coast; minor shocks followed in places to January 15, 1868. There was not at that time any eruption in the north country, but from August 27 to September 5 there had been an eruption in the Vatna Jökull in the south-east of the island. II

1872 A great earthquake was felt at Husavik and Akureyri in the night of April 18; it was felt also at several other places along the north coast. II

1874–5 From the week before Christmas to January 3, 1875, frequent but moderate shocks occurred in Myvatnsveit and throughout the Nordurland, mostly inland. Shocks continued near Myvatn to the spring, while eruptions took place in Dyngjufjöll, January 3, and again March 29, and also in the Myvatnsöræfa on February 18, but they were not of importance. I

1882 October 29, there was an earthquake in several places on the north coast, principally round Thistillfjördr, a bay near the north-east corner of the island.

December 21. The same district was affected, particularly Akureyri. I

1884 November 2. Sharp earthquakes occurred at Husavik, Kelduhverf, and Thistillfjödr. I

1885 January 25, a severe earthquake at Kelduhverf and elsewhere along the north coast. III

1897 May 3. Earthquakes occurred along the western part of the north coast. I

1899 In the early part of this year there were frequent but not severe earthquakes in Iceland generally. The strongest occurred on January 30 and 31, and February 26–28, along the north coast from Bordeyri on the Hunaflói to Akureyri. On the west coast it was felt at Holt, on the Onundarfjördr, February 26, and on the same day at Reykjavik. On the 27th shocks were felt at Eyrarbakki in the Sudurland. At Bordeyri the direction is stated to have been south-east to north-west, at Grimsey the shocks were thought to come from south and south-west. I

Besides the three lists above abstracted, Mr. Thoroddsen's book contains a general list of recorded volcanic eruptions and earthquakes in all parts of Iceland, among which the following may be noted, which are not included in the lists given above, as they occurred in Skaftafellsysla, which is not comprised in the Sudurland, but lies to the east of it.

1721 On May 14 strong earthquakes were connected with the eruption of the Katla in the Myrdals Jökull; they extended to Eyjafjöll and Fliótshlid in the Sudurland.

1727 August 2. There was a severe earthquake at Sandfell near the Oræfa Jökull in connection with an eruption of that volcano.

1783 June 1, a severe earthquake shook Skaftafellsysla; the disturbance lasted till June 8, when the great Skaftárgos, an enormous eruption from Skafta fell, commenced.

A Provisional List of Destructive Earthquakes of the Southern Andes, south of Lat. 16° (S. Peru, Chile, Bolivia, W. Argentina).

By Count MONTESSUS DE BALLORE.

The relative 'destructivity' of different shocks are indicated by the numerals I, II, and III, see p. 57.

A.D.	
1520 (?)	S. Provinces of Chile. (?)
1543	Tarapaca. (?)

A.D.		
1562	Oct. 28.	La Imperial, Coast of Arauco. Sea waves. III
1570	Feb. 9.	Concepcion. Sea waves. III
1575	Mar. 17.	Santiago. II (?)
1575	Dec. 16.	La Imperial as far as Castro. Sea waves. III
1582	Jan. 16.	Arequipa. III
1588		W. Coast of S. America. (?)
1604	Nov. 24.	Arica and Arequipa. Sea waves. III
1604	Dec.	La Serena. (?)
1615	Sept. 16.	Arica. III
1632		Esteco (province of Salta). (?)
1633	May 14.	Carelmapu. Earthquake (?). Hurricane
1643	Sept. 6.	Santiago. I
1647	May 13.	Santiago. III
1650	Nov. 10.	La Paz. II
1657	Mar. 15.	Concepcion. Sea waves. III
1681	Mar. 10.	Arica. (?)
1688	July 12.	Santiago. (?)
1690	July 9.	Santiago. (?)
1692	Sept. 13.	Esteco (Tucuman). (?)
1715	Aug. 22.	Moquegua. (?)
1724	May 24.	Santiago. (?)
1725	Jan. 8.	Lima and Arequipa. III
1730	July 8.	Concepcion. Sea waves. III
1734		Mision of Tarija in el Chaco. (?)
1737	Dec. 24.	Ruin of Valdivia. III (?)
1742	Mar. 23.	North of the peninsula of Patagonia, south of the Archipelago of Chonos (Territory de Magellan). I (?)
1751	Mar. 25.	Concepcion. Sea waves. III
1773	July 29.	Copiapo. III (?)
1775	Mar. 17.	Valparaiso. I (?)
1782	May 22.	Mendoza. (?)
1784	May 13.	Arequipa, Arica. (?)
1784	Good Friday.	Arica and Valley of Tambo. II
1787	Feb. 1.	Castro. I (?)
1787	Mar. 23.	Arequipa. I
1792	Nov. 30.	La Serena. (?)
1793	Aug. 7.	Arica. (?)
1796	Mar. 30.	Copiapó and Vallenar. III
1801	Jan. 1.	La Serena. III
1813	May 30.	Yca and Arequipa. (?)
1819	April 4, 3, 11.	Copiapó. III
1821	July 10.	S. Peru, Camana and Arequipa. III
1822	Nov. 5.	Copiapó and Coquimbo. II
1822	Nov. 19.	Valparaiso. Sea waves. III
1829	Sept. 26.	Valparaiso and Santiago. I
1829	Oct. 1.	Santiago. I
1831	Oct. 8.	Arica. I
1833	April 25.	Huasco. I
1833	Oct. 18.	Arequipa, Arica and Tacna. II
1834	July.	Yca. (?)
1835	Feb. 20.	La Concepcion and Talcahuano. Sea waves. III
1836	July 3.	Cobija. Sea waves.
1837	Nov. 7.	Valdivia. III
1843	Dec. 17.	La Serena. I
1844	Oct. 18.	Salto, Tucuman, Santiago del Estero. III
1845	June 3.	Arica. I
1847	Jan. 19.	Copiapó. I
1848-50	(?)	Santa Cruz de la Sierra (Bolivia). II
1849	April 9.	Destruction of San Luis (Argentina). III

A.D.		
1849	Dec. 17.	Coquimbo. With sea waves. I
1850	Dec. 6.	Santiago. II
1851	April 2.	Santiago. II
1851	May 26.	Province of Atacama. II
1854	Jan. 14.	Minas de Cruz de Cañas (Coquimbo). I
1859	Oct. 5.	Copiapó. I
1861	Mar. 20.	Mendoza. III
1861	Aug. 29.	San Carlos (Argentina). I
1862	Feb. 5.	Mendoza. I
1863	June 29.	Arequipa. I
1864	Jan. 12.	Copiapó. I
1866	July 23.	Copiapó. I
1868	Aug. 13.	S. Peru, Bolivia and North of Chile. Sea waves. III
1868	Oct. 12.	Copiapó. I
1869	Aug. 19.	Arica to Yca. Sea waves. I
1869	Aug. 24.	N. Chile and South of Peru. I
1870	Mar. 23.	Calama. (?)
1870	Mar. 25.	Mendoza. I
1871	Feb. 23.	Province of Cochabamba (Bolivia). II
1871	Mar. 24.	Santiago, Valparaiso. I
1871	Oct. 5.	Tarapacá. I
1871	Oct. 22.	Jujuy and Oran. III
1873	July 7.	Central Chile. III
1874	Oct. 26.	Santiago. I
1876	Feb. 11.	Illapel, Salamanca and Chalinga. II
1877	May 9.	N. of Chile, Iquique. Sea waves. III
1877	May 17.	La Paz. I
1878	Jan. 23.	Iquique, Arica, Province of Tarapacá. I
1879	Feb. 2.	Magellan Territory and Tierra de Fuego. I (?)
1880	Aug. 15.	Valparaiso, Illapel and Quillota. I
1882	Mar. 6.	Department of Paclin (Catamarca Argentina). II
1883	Oct. 1.	Arequipa. I
1884	Nov. 26.	Bolivia. I
1887	Sept. 23.	Yacuiba (Bolivia). I
1890	April 24.	San Felipe. I
1891	Aug. 15.	Central Bolivia. I
1894	Oct. 27.	La Rioja and San Juan. II
1898	July 23.	Concepcion. I
1899	April 12.	La Rioja, Catamarca, Tucuman, Rio Cuarto, Santiago del Estero. I
1900	Oct. 23.	San Luis. I
1903	Aug. 12.	Mendoza. I
1903	Dec. 7.	Vallenar. II
1904	Mar. 19.	Vallenar. II
1906	June 18.	Valparaiso and Valley of Aconcagua. II
1906	Aug. 16.	Valparaiso and Central Chile. III
1907	June 13.	Valdivia. II
1907	Aug. 14.	Mendoza. I
1908	Feb. 23.	Sierra Gorda (Antofagasta). I
1908	July 16.	N. Chile, S. Peru, W. Bolivia. I
1909	Feb. 11.	Candarave (S. Peru). I
1909	May 17.	Tupiza (Bolivia). II
1909	June 8.	Chañaral and Copiapó. II
1909	July 22.	Sipesipe (Cochabamba, Bolivia). III
1909	Sept. 20.	Tinogasta, W. Argentina. I