To this statement it is only necessary to add that Dr. E. Schunck will preside over Section B (Chemistry), and Prof. A. Newton over Section D (Biology).

## *THE JAPAN EARTHQUAKE OF JANUARY* 15, 1887.[1]

SOON after the occurrence of the earthquake of January 15 last, which caused considerable damage to property in and near Yokohama, the authorities of the Imperial University directed the writer to visit the places which had been affected by the shock, and to make a full report of all the circumstances. The results thus arrived at form the subject of the present paper. Before proceeding with this, however, it seems desirable to give some particulars respecting the principal shocks which have been felt in the Empire since 1879.

The earthquake of February 22, 1880, is the severest that has been experienced in the Plain of Musashi during the last ten years. The damage done to buildings was very much greater than on the recent occasion. Its origin was in the Bay of Tōkyō.

On October 25, 1881, Nemuro, in Yezo, was visited by a somewhat destructive shock. Fissures were opened in the ground, and the damage to property was not inconsiderable.

The well-known Atami Spa and its neighbourhood were convulsed on the morning of September 29, 1882, by a sudden and severe movement, which damaged embankments, destroyed an historical monument, and did sundry other mischiefs.

The earthquake of October 15, 1884, originated in the Bay of Tōkyō, and affected the Plain of Musashi. It overturned a considerable number of chimneys, cracked walls, and broke articles in museums and elsewhere. In Tōkyō, the greatest horizontal movement, in a soft ground, was 42 mm., or double the amount observed on January 15 last. However, the total damage, taking the whole affected area into account, was smaller.

The seismic waves in the disturbance of October 30, 1885, extended over the whole of Northern Japan and part of Yezo, shaking a land area of 34,738 square miles. But, though of great extent, they fortunately did little harm.

On July 23, 1886, quite a destructive earthquake visited Shinano and the neighbouring provinces, overthrowing several houses, and forming fissures in roads and hill-sides. The shock also stopped the flow of a hot spring at Nozawa. The part most severely shaken was a mountainous district some 2000 feet above the sea, including the famous active volcano of Asama, and many extinct craters. This case was an unusual one, as most of the larger earthquakes in Japan extend along the sea-shore.

Next in the list comes the severe shock of last January.

It thus appears that this Empire is visited by a more or less destructive earthquake *almost once a year*, and that the Plain of Musashi is affected in like manner *at intervals of a few years*.

The shock of last January was of most unusual violence. It originated near the coast, about 35 miles south-west of Tōkyō, and the seismic waves propagated nearly 200 miles to the west and north-east along the Pacific seaboard. On the north-west they approached but do not quite reach the shore of the Japan Sea. They shook, in all, about 32,000 square miles of land area.

In Tōkyō the disturbance began at 6h. 51m. 59s. p.m., with slight tremors. After thirty seconds from the commencement, the greatest horizontal motion (21 mm.) was recorded. The time taken to complete one to-and-fro motion of the ground was 2·5 seconds. The maximum vertical motion was only 1·8 mm., being, as usual, very small compared with the horizontal movement. The principal motion continued for more than two minutes, during which time no less than *sixty distinct shocks* occurred. The maximum velocity and maximum acceleration, which measure the overthrowing and shattering power of earthquakes, have been calculated from the above numbers, and found to be respectively 26 mm. and 66 mm. per second. These numbers, considering the range of motion, are small; or, in other words, the oscillations of the ground were comparatively gentle and slow, which serves to explain the fact that but little harm was done to property in the capital. In Yokohama, Hipp's seismograph registered a horizontal motion of 35 mm.

The origin of the shock was in a narrow band of country running from west to east in the province of Sagami, parallel to the coast, at a distance from it of about seven miles. It emanates from the western or mountainous parts of the province, passes through the southern foot of Oyama (4125 feet above the sea-level), and reaches the Bay of Yokohama in a total distance of about 30 miles. I believe the most probable cause of the shock to have been faulting or dislocation of the earth's crust along the band above named. This inference is supported by the fact that the parts of the country through which the western half of the band passes consists of rocks of different geological formations, interwoven in such a way that their junctions present lines of weakness favourable to earth-snaps. The topographical features of the district—high mountains on the north, and comparative low plateau and sea-shore on the south—also lend strength to this conclusion. Unequal distribution of loads on the earth's surface tends to facilitate bending and folding of the rocks.

It is along the above-named axis or band that the effects were most striking. They were mainly confined, however, to a small breadth on either side of it, so that places as little as two or three miles to the north or south experienced a well-marked diminution of seismic energy. This is not the first instance in the history of the severer shocks in which the destructive effects have been practically limited to a small area near the origin.

More especially on the hilly or western portion of the origin, land-slips and cracks were numerous. The cracks mostly took place in banks, hill-sides, or other situations favourable for their formation. The writer counted no fewer than seventy-two in a distance of seven miles, the largest measuring a foot wide and five hundred feet long, and all of them running parallel to the axis of origin, which is also parallel to the general contour of the country. Several wells became turbid. In some of artesian character the water permanently decreased; in others it increased. There is a ferry across the large river Banyū where it is crossed by the axial band; but the water was so agitated by the shock that for some time afterwards the boat could not be used. The water in one of the rivulets on the west became muddy. The shock was severely felt on board of vessels in Yokohama harbour, the people in many of them rushing on deck under the impression that they had been run into. The effects upon these vessels were doubtless caused partly by motion communicated through the cables, and partly by agitation of the water due to movements of the sea-bottom. The earthquake was preceded by the usual warning roar or rumbling, as of distant cannon, emanating apparently from the western part of the origin-band. In that district, too, the after-shocks on the same night were five in number, while in Tōkyō there was only one. There were four tremors near the origin during the night of the 16th.

Dwelling-houses in country towns and villages are always built of wood. Their frame-work is of timbers from four to seven inches square, crossing one another at right angles. The uprights are placed about three feet apart, and stand on rows of squared stones or boulders, the intervening spaces being filled with bamboo-laths, on which is laid the mud-plaster that forms the walls. Tiles and straw are principally used for the roof-covering. In the district near the origin these wooden houses shook with great violence. Several of them were more or less twisted, cracked, or unroofed. Sliding doors, covered with paper or of wood, which serve as shutters, partitions, and windows in Japanese houses, broke and were shot out of their grooves. The joints between the frames were in some cases badly loosened. Although there are thousands of wrecked houses, in the district of origin, on the verge of falling down, and looking as if a strong breeze would be enough to blow them over, the buildings of this class nevertheless withstood the violence of the earth movements so far as to escape actual demolition. The writer saw only two small rotten hovels which had

[1] Paper by S. Sekiya, Professor of Seismology, Imperial University, Japan. Reprinted from the Journal of the College of Science, Imperial University, Japan, vol. i. part iii. The earthquake, the distribution and effects of which are described in this paper, is the shock which formed the subject of an article in NATURE for June 2 (p. 107), in which one of the autographic records obtained by the author with Prof. Ewing's seismographs was reproduced in *facsimile*. The diagram in question, which showed a greatest horizontal movement of 7½ millimetres, was one of those referred to near the end of this paper as having been obtained on the stiff elevated soil where the University is built, and where the amplitude of the motion was little more than one-third of the motion shown by seismographs of the same construction on the lower alluvial soil.

been thrown down. This circumstance shows the tenacity of wooden framed structures. Prof. T. Mendenhall, in a report[1] on the recent catastrophe at Charleston, says:—"As was to be expected, buildings constructed of wood suffered much less than those of brick. The interior of wooden buildings, however, would often exhibit a scene of total destruction, furniture, book-cases, &c., having evidently moved with great violence."

Fire-proof stores, or *Kura*, suffered severely as to their walls. These buildings have wooden frames, strongly joined by horizontal and vertical pieces, and closely covered with laths, the whole making up a compact box-like structure. The roof is tiled, and carefully plastered with a mud which has a slight cementing property, to the thickness of from three to nine inches. This plaster is put on in several layers, each layer being added after the preceding one has dried. The whole process is an expensive one. The walls, on account of their great thickness and the poor tenacity of the mud, are easily cracked or stripped. As many as sixty or seventy per cent. of the *Kura* suffered from the recent shock. It is evident that these thick-walled structures should be replaced by brick buildings, which are equally fire-proof and much stronger.

It may be mentioned, however, that the frameworks of *Kura*, after having been entirely stripped, have withstood the most violent earthquake on record.

In Yokohama, houses are built of different types and with a variety of materials, so that they afford a fair field for the comparison of seismic effects. It is very fortunate that, judging from the effects wrought by the recent earthquake on both land and buildings, the seismic intensity in this town was less than one-third of that in the western or hilly parts of the origin-band. But for this, the results would have been highly disastrous.

The houses which suffered most were the composite structures of wood and stone. They are built of wooden frames encased with stone blocks, each of the latter measuring 2 feet 9 inches long, 9 inches wide, and 6 inches thick, and being clamped to the wooden planks inside by three iron nails. The nail, called *Kasugai*, is 5 inches long and $\frac{7}{10}$ inch square, and bent at right angles at its two ends. The stone is soft and brittle, being volcanic rock of the worst quality. In time the iron nails get rusty, and the stones are so acted on by rain and frost as to be easily cracked, or detached from the wooden frames, even by moderate shakings. These buildings, erroneously called European houses, already exist in abundance, and unfortunately increase each year in number. They are generally constructed with bad materials and on faulty principles; the object of the builders being to attain fair protection from fire, along with the appearance of a stone building, at the least practicable cost.

Two brick structures received serious damage, cracks having been formed, as usual, at the corners of the buildings and over the windows. The seismic vibrations, however, left no traces on the Town Hall, the Custom House, Prefectural Office, and other well-built structures of brick or stone.

In Yokohama, wooden houses sustained no damage worth mentioning. Joints were more or less loosened and tiles occasionally fell down from the roofs. The tiles that are fastened to the framework of wooden houses, to form walls, were in some cases detached in large quantities. There are decidedly many improvements which might be made in the present wooden buildings, both of Japanese and so-called European styles, especially in the arrangements of their joints, the scientific distribution of materials, &c. If these and other defects were properly remedied, such dwellings might be made pretty safe as against earthquakes. In sites little liable to danger from fire, one may find, in this country, wooden houses built three and even four centuries ago. Wood, no doubt, will continue for a long time to be the chief building material in this country.

In Japan, however, fire is a more constant and even more dread enemy than earthquakes, while terrible conflagrations are often brought about by destructive shocks. Hence, brick and stone should, and probably will in time come to be largely employed for building, especially in towns. The question, then, is to select certain types of brick or stone houses which are best calculated to resist earthquake shocks. Sheet and bar iron houses, as used in Australia, would make very efficient earthquake-proof buildings, although they are not free from several objections.

After the terrible catastrophe of 1883 in the Island of Ischia, the Italian Government appointed a Commission[1] to consider the reconstruction of the buildings in that island. The Commission, after investigating the different modes of construction most suitable for earthquake countries, submitted models of houses in wood, and in combinations of wood and masonry, which were adopted. The Commission recommended that buildings should be chiefly constructed with an iron or wooden framework, carefully joined together by diagonal ties, horizontally and vertically, the spaces between the framework being filled in with masonry of a light character. Not more than two stories above ground were to be allowed, &c., &c.

In Italy, brick houses are joined by iron tie-rods; and similar devices are now, to a certain extent, used in this country. Concerning the erection of brick or stone houses in Japan, much valuable information is to be obtained from the Italians, who, like ourselves, have lived for centuries amidst terrible shakings, and who, no doubt, have gained much experience in the constructive arts suitable to the conditions of our existence here.

A prominent feature in the effects of the recent earthquake was the overthrowing of brick chimneys in Yokohama, especially on the Bluff. Soon after the shock, circulars were sent round to the principal residents, asking for information as to the effects of the shock on the buildings occupied by them. More than fifty answers were received, and the facts embodied in them have been of great value in preparing this paper. The writer takes this opportunity of expressing his warmest thanks for the kind assistance thus rendered to him. From these answers, from the Police Reports, and from actual observations, fifty-three chimneys appear to have been destroyed. In one instance a heavily-coped chimney fell in a large mass through the roof, and severing a strong beam of 1 foot by 8 inches on the second story, penetrated to the ground floor.

About one-half of the chimneys thrown down during the shock were cut in two at their junction with the roof; while some dislodged the tiling and did sundry other damage to the buildings at their points of contact. Evidently the chimneys and the houses moved with unequal range and with different vibrational periods. Prof. Milne has more than once recommended that chimneys should be built thick and squat, without heavy ornamental mouldings or copings; and be, if possible, disconnected from the roofs. Those houses in which his suggestions had been adopted suffered no damage on January 15.

Generally, the relations of the seismic effects to the geological, topographical, and other features of the various localities were found to corroborate previous experience. That the seismic vibrations in hard ground are very much less than in soft soil was well illustrated on the recent occasion. At the University, where the ground is hard and firm, the seismograph recorded only 8 mm. horizontal motion, as compared with 21 mm. registered by a similar instrument placed on soft soil a mile distant. Totsuka is a small town, with a single long street running along the foot of a hill; one side of the street, however, is built on made-up ground. Most serious damage was done on that side, while the opposite houses suffered very much less, though not more than twenty feet distant. Houses built on cliffs and hill-brows received more damage than those situated at the base or on the flat summits of the same hill. To observe the effects of marginal vibration, the writer recently placed one seismograph at the steep edge of a loamy hill thirty-eight feet in height, and another similar instrument at its foot. The motions, thus far measured, at those two levels are found to be in the ratio of 2 to 1. A third instrument will shortly be set up on the flat summit of the same hill. Observations of a similar nature, on different rocks and at various heights, will form the subject of a further paper. It is probably owing to marginal vibration that houses on the Bluff of Yokohama are always heavy sufferers from earthquakes.

The extensive and rapidly increasing use of kerosene lamps in Japan constitutes a grave danger in severe shocks. The lamps now in common use are of very brittle materials, contain the most combustible of oils, and are usually poised on ill-balanced stands. In the great earthquake of 1855, at a time when kerosene was unknown in this country, fire broke out in Yedo at more than thirty points, setting a very large part of the city in a blaze. In the event of another such shock, the mischief which would be produced from this cause alone is awful to contem-

[1] The *Monthly Weather Review*, U.S. Signal Service, August, 1886.

[1] Proceedings of the Institution of Civil Engineers, vol. lxxxiii., Session 1885-86, part i.

plate. Great credit will be due to any one who can invent a convenient earthquake safety-lamp, which, it is to be observed, will also constitute a valuable safeguard in ordinary daily life. It is true, so-called safety-lamps are sold in Tōkyō, but they are very ineffective and miserable affairs. The use of metallic oil-holders would doubtless greatly lessen the danger.

During his inquiry the writer was shown sixteen lamps that had been broken in the recent earthquake. In one instance the kerosene caught fire, and it was with great difficulty that the residents extinguished it by the aid of wet mats.

## *MINERALS AT THE AMERICAN EXHIBITION.*

ONE of the most conspicuous features of the American Exhibition is the remarkable collection of minerals brought over and exhibited by Mr. A. E. Foote, of Philadelphia. Many of the specimens, which are extremely fine, have been obtained during collecting-expeditions undertaken by Mr. Foote himself, and several new species and varieties have been made known to science through his indefatigable labours.

The central feature is a hexagonal pavilion covered with mica, and surmounted by a model of a snow crystal. Each side of the pavilion is devoted to a separate mineral region of the North American continent—except the first, which is filled with a collection of gems and ornamental stones. Here are rough and cut specimens of a precious ruby, topaz, opal, williamsite, with examples of malachite and azurite beautifully banded and taking a fine polish.

A lapidary who has had several years' experience in making rock-sections for the British Museum is constantly employed close by.

Minerals from the region near the Pacific coast come next. Wulfenite, a rare species, some the finest specimens ever seen, is here exhibited in large groups of orange-red crystals; also brilliantly red vanadinites and large bright crystals of chessylite or azurite associated with velvet tufts of malachite. All these are from the marvellous country that Humboldt called New Spain. The deep-red garnets from Alaska in their sombre settings of gray mica-schist are especially noteworthy. Among the minerals of the Rocky Mountain region are wonderful crystals of the green Amazon-stone; ore from the famous Bridal Chamber at Lake Valley, New Mexico, so rich that the heat of a match will cause it to melt and fall in drops of nearly pure silver. A space the size of a moderate-sized room produced about £100,000. The precious turquoise comes from Los Cerrilloz, New Mexico, where Montezuma got his chalchuhuitls that he valued above gold and silver. The Indians still make long pilgrimages for the sacred stone.

Most striking among the minerals of the Mississippi Valley and Lake region are the blendes and galenas from South-West Missouri, a district that now produces over one-half of all the zinc mined in the world. It was formerly so abundant that farmers built their fences with it. Masses of the lead-ore weighing ten tons were found within 12 feet of the surface. Here Indians formerly procured the lead for their bullets, placing the ore in hollow stumps and building a fire over it.

From Arkansas come fine rock-crystals or hot-spring diamonds, with powerful lodestones, arkansites, and hydrotitanites.

From the Lake Superior region come copper, chlorastrolites, and zonochlorite, a remarkable gem-like mineral.

In the case devoted to the North Atlantic coast region is rhodonite, so much used by the Russians in their ornamental work, in fine crystals. The mines at Franklin, N.J., produce also many minerals found nowhere else in the world, such as franklinite, named after the illustrious philosopher; anomolite, a new species recently described by Prof. G. A. König, of the University of Pennsylvania; troostite, jeffersonite, blood-red zincite, &c., &c. Cacoclasite, a new species in fine crystals, associated with pink titanite, comes from the same region, as do the remarkable crystals of apatite. These are among the finest specimens ever seen, and associated with them are the brilliant twin-zircons. From the apatite are manufactured hypophosphites to stimulate the appetite, and superphosphates to grow wheat and corn.

The last case devoted to the South Atlantic coast region contains amethysts, sapphires, aquamarines, tantalite, gummite, and uranolite, huge sheets of mica, &c., &c.

Next to the wall opposite is a very extensive collection illustrating the mineralogy of Pennsylvania, which, besides the well-known coal, iron, and other ores that have made the State famous, includes very extraordinary specimens of the rare mineral brucite, from which the medicine, Epsom salts, may be made; diaspore in fine crystals, corundum for polishing purposes, chromite for producing brilliant yellows, &c., &c.

Adjoining, in cases and drawers, are the college and educational collections indispensable for the studies of mineralogy, geology, and chemistry.

The collection of American Geological Surveys and other scientific works is very extensive, over fifty volumes from Pennsylvania alone being shown. We have devoted so much space to the description of the extensive exhibit made by Mr. A. E. Foote, of Philadelphia, that we can only refer to the minerals shown by Kansas and other States, by the Denver and Rio Grande and C. B. and Q. Railroads, and by various mining companies.

## *THE FOLK-LORE OF CEYLON BIRDS.*

A CORRESPONDENT of the *Ceylon Observer* of Colombo, referring to the interest excited by Mr. Swainson's new book on "The Folk-Lore and Provincial Names of British Birds," notes some points in the folk-lore of the birds of Ceylon, obtained largely in conversation with natives. The devil-bird (*Syrnium indrani*) stands *facile princeps* for his evil reputation; his cry heard in the neighbourhood of villages is a sure harbinger of death, and the superstitious natives are thrown into great consternation by its demoniac screech. The legend about the bird is as follows:—A jealous and morose husband doubting the fidelity of his wife killed her infant son during her absence and had it cooked, and on her return set it before her. She unwittingly partook of it, but soon discovered that it was the body of her child by a finger which she found in the dish. In a frenzy she fled to the forest, and was transformed into a *ulania*, or devil-bird, whose appalling screams represent the agonized cries of the bereaved mother when she left her husband's house. The hooting of owls in the neighbourhood of houses is believed to bring misfortune on the inmates. The magpie robin, though one of the finest of the song-birds of Ceylon, is similarly tabooed; it has a harsh grating screech towards evening, which is considered ominous. The quack of the pond heron flying over a house is a sign of the death of one of the inmates, or of a death in the neighbourhood. If the green pigeon (*Nila kobocya*) should happen to fly through a house, as it frequently does on account of its rapid and headlong flight, a calamity is impending over that house. Similarly with the crow. But sparrows are believed to bring luck, and are encouraged to build in the neighbourhood of houses, and are daily fed. The fly-catcher bird of Paradise is called "cotton thief," because in ancient times it was a freebooter, and plundered the cloth merchants. As a penalty for its sins it was transformed into a bird and doomed to carry a white cotton attached to its tail. The red wattle lapwing, the alarm bird of sportsmen, has the following legend connected with it:—It is said to represent a woman who committed suicide on finding herself robbed of all her money, amounting to thirty silver pieces, by her son-in-law. The cry of the bird is likened to her lament: "Give the silver, give the silver, my thirty pieces of silver." Its call is heard at all hours, and the stillness of night is broken with startling abruptness by its shrill cry. Another story about it is that when lying in its nest in a paddy field, or a dry spot in a marsh, it lies on its back with its legs in the air, being in continual fear that the heavens will fall and crush its offspring. The story current about the blue-black swallow-tailed fly-catcher (*Kawudu panikkia*) and its mortal enemy, the crow, is that the former, like Prometheus of old, brought down fire from heaven for the benefit of man. The crow, jealous of the honour, dipped its wings in water and shook the drippings over the flame, quenching it. Since that time there has been deadly enmity between the birds. The Indian ground thrush (*Pitta coronata*) is said to have once possessed the peacock's plumes, but one day when bathing the peacock stole its dress; ever since the *Pitta* has gone about the jungle crying out for its lost garments. According to another legend, the bird was formerly a prince who was deeply in love with a beautiful princess. His father sent him to travel for some years, and on his return the princess was dead. He still wanders disconsolately about calling her name. It is also said that the peacock, being a bird of sober plumage, borrowed the brilliant