

EARTHQUAKES IN CHINA.

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I had prepared, for presentation to the Seismological Society of Japan, a tabulated account of earthquakes that have been recorded since the Confucian era in Chinese Annals, but it was destroyed by fire during a riot last winter, and with the paper were destroyed also the works from which the facts were derived. Perhaps, however, some general remarks which those records suggest may not be devoid of value.

Nothing can be inferred anent the relative frequency and distinctiveness of earthquakes in ancient and modern times from Chinese history; from the earliest named earthquake, that of Mount T'ai in Shantung, 1831 B.C., to the commencement of the Han dynasty, 200 B.C., only twelve are recorded; tradition, and written archives, noting those only that presented extraordinary features,—a bald list, merely mentioning a disturbance of the rivers Jo So (1808) in Honan, of the Wei, Chin and So, in Shansi (778 B.C.); formation of long chasms in the loess (in 345 and in 206 B.C.) etc. From the Han period onward notices of similar phenomena increase of course, accompanied betimes with a few details mainly relating to loss of life and succour afforded to survivors. Geographically considered, earthquakes in China may be grouped as insular, littoral, and inland.

On the island of Formosa earthquakes are hardly less frequent than in Japan, while on Hainan they are comparatively of rare occurrence. These islands form a portion the great volcanic chain that girdles the coast of Eastern Asia, the

Chinese portion rising from the hundred fathom submarine plateau that overlooks the profound abyss of the Pacific ocean.

Insular earthquakes affect the mainland but seldom and to a slight extent, although so near the least stable portion of the earth's surface. Formosan throes extend across the channel, which is fifty-two fathoms deep and sixty-three miles wide. Japanese earthquakes are rarely if ever felt on the adjacent peninsula. The Korean strait is twenty-six miles wide and ninety-three fathoms in depth. The facts lately made known by Professor Milne, that earthquakes in Japan largely disturb alluvial regions, and that eighty-four per cent. of the whole number originate in the Pacific, partially explain Korean exemption from the shakes of the contiguous archipelago.

The absence, from Chinese and Korean annals, of all reference to earthquakes in that peninsula, long inclined me to regard Korea as comparatively exempt from seismic action, and recently I addressed Consul E. H. Parker of H.B.M.'s Service in that country for information, who obtained from the prefect of Chemulpo a communication on the subject, the purport of which is, that earthquakes are so infrequent and harmless, that records are not made of their occurrence. It is more than ten years since an earthquake was experienced in that kingdom, and on that occasion no one was injured nor were buildings thrown down. No information is obtainable on the subject from Manchuria, where presumably earthquakes are uncommon. There is, however, a record of a volcanic eruption having occurred about a century ago in that portion of the empire.

The only existing volcanic action on islands off this coast is on the north of Formosa, near Keelung, where a solfatara is in ceaseless ebullition, affording large supplies of sulphur, and emitting, during earthquakes, so much hydro-sulphuric gas as to occasion malaise to the residents and to discolor the white paint of ships.

Information respecting Formosan earthquakes is so scant,

that the following from a Chinese writer is worth citing. It relates to an earthquake that occurred in northern Formosa in the 5th month of 1693. "During that month the earth shook without cessation. A tract of country in which three villages were situated caved in; the inhabitants, however, had time to escape." Three years after that submergence, the narrator, a mandarin who was on his way to procure sulphur from the solfatara, "could see in a lakelet, where the water was shallow, the tops of bamboos and trees of those villages. While near the solfatara, he heard for a day and night noises that resembled a cataract precipitated from a lofty cliff; the sound seemed to be near and all about, but no evidence of the cause of the noise was discoverable. When, however, he arrived at the geyser, the mystery was explained; he there heard the same sounds like a rushing of subterranean waters."

Formosan earthquakes occasionally cause tremors to be felt on the mainland. These have the ordinary direction of earthquakes on that island, which are generally from N.E. to S.W. or the reverse in the North, and in Southern Formosa run north and south. The Liu-chiu group is the centre of seismic forces that do not appear to extend beyond those islands.

Submarine disturbances not unfrequently attend the insular earthquakes. The sea sometimes rises on the Formosan coast sixteen feet above the usual high tide level. Independently of the terrene commotions of Formosa, its adjacent waters appear to be subject to submarine agitations, occasioning what records of the mainland style "third" or supplementary tides; but these are of rare occurrence. The "tide-rips" that have attracted the attention of hydrographers are notable phenomena, but the following, from a local gazetteer, seems to indicate the existence of phenomena that cannot be referred to tidal action. "Peculiar noises of the sea are sometimes heard which are commonly regarded as indicative of change of weather, sounds from the North foreboding rain, those from the South being followed by wind. Hissing noises are heard; at times they are low, at

others loud ; when low, they resemble the beating of a drum or the dropping of beans on that instrument ; now, the sounds are near, anon they are distant ; stopping suddenly or continuing for hours. When the noise is loud, it is more noisy than the voices of a hundred thousand men, and the sea bubbles up ; in very protracted cases, the noises continue day and night for half a month ; and when of short continuance, the sound lasts three or four days. Coastlanders err in supposing that these noises have connection with the weather. They are observable during rains and in drought, in wind and in calms. During the sounds, the sea is agitated by fearful billows and furious waves." If that extraordinary seething and roaring of the ocean were synchronous with earthquakes, the fact could not have escaped observation ; undubitably that graphic description applies to submarine volcanic action ; to which, also, I attribute the supplementary tides of the adjacent coast. Some thirty years ago an island was thrown up by a submarine volcano on the South of Formosa. The pumice that is cast upon the northern shore of that island is evidently a submarine production.*

As proximity to the belt of volcanic islands seldom disturbs the mainland of the northern littoral, so the adjacent coast of Southern China and Annam enjoy like exemption from insular throes. Chehkiang and Fuhkien are sometimes slightly joined by Formosan shocks, and even the Canton coast slightly, but Philippine earthquakes never affect Annam.

Earthquakes on the coast of China are frequent, but slight and harmless. Their harmlessness is evinced by the tall slender pagodas that adorn the hills and valleys, and they are generally very limited in area, with great diversity of direction, but a majority being from S.W. to N.E.

Kwangtung and Kwangsi are very rarely subject to earth tremors, and Tonking never. Observing the rarity of seismic

* For an account of the volcanic region of Northern Formosa, see Mr. Hancock, in *Imperial Maritime Reports*, 1881.

phenomena in the records of Southern China, I enquired of M. Legrand, of Haiphong, who informs me that, since the French became acquainted with the province of Annam, no earthquakes have been experienced, nor, on inquiry, could natives be found who had heard of an occurrence of the kind. I am of opinion that Indo-China generally is exempt from earthquakes.

The tremors that are experienced in Chehkiang, Kiangsu, and coterminous regions to the West, are sometimes followed by the appearance on the ground of substances that in Chinese books are styled "white hairs, several inches in length, like horse-tail hair."

When I first called attention to records of that kind that are found in local gazetteers, I suggested that they might be crystals precipitated by gaseous emissions, such as were once reported as occurring after an earthquake in the South-west of the United States. From later descriptions of these "horsetail like" substances, I incline to the opinion that they are organic, perhaps mycillium.

In the summer of 1878 the vernacular press gave an account of the occurrence of the phenomena at Wusoh, a city on the grand canal, 30 miles North of Suchau. "At noon, June 12th of that year, shocks of an earthquake were experienced which lasted several minutes (lit. 'for the space of time taken in swallowing half a bowl of rice'). The motion was so great that sitting or standing was difficult; but no harm was done. Two days later, at night, there was a severer shock, after which within and without the wall of the city, white hairs resembling a silvery beard about three inches in length were found, which boys pulled out of the ground, gathering a handfull in a short space of time." My list of Chinese earthquakes for the past two thousand years having been nearly all destroyed by fire, I am unable to indicate the regions in which earthquakes were followed by the emission of "hairs," but my impression is that all, or nearly all, are alluvial vallies.

The chief foci of inland earthquakes are Szechuen, Shensi, and Kansuh, and less frequently Shansi, Chihli, Shantung, and the central provinces, where the intensity of seismic action is greater than in other portions of the empire and frequently presents continuous or protracted movements; for example a series of earthquakes occurred at Taiyuan, the capital of Shansi, in 1882, followed by shocks at brief intervals for a year. An earlier series occurred in the province of Chihli; the district city of Ch'üchow suffered most, not a house remained standing, and many lives were destroyed; frequent shocks occurred for a year after. The province of Szechuen is also liable to a continuance of seismic throes; one of these commenced in the fourth month 1462, and continued eleven months,—there were in all 375 shocks.

In the loess formation of Northern China (discovered and described by Baron Richthofen) the land is not unfrequently riven by earthquakes forming long narrow chasms of unknown depth that gradually disappear, due to the vertical cleavage and unstratified nature of loess.

In the first decade of the 4th month, 1828, an earthquake caused a fissure over three miles in length and 20 to 30 feet broad, from which a vapour issued that proved fatal to many; people, animals, houses and tombs were engulfed. About two months later, during heavy rains, the chasm gradually filled up.

The earthquake region of China lies in a great seismic zone, which extends from near the Gulf of Chihli to the shores of the Caspian, including Turkestan and the Uralo-Caspian depression. In Eastern Turkestan they present a periodic character, five per annum with remarkable regularity; yet there are few portions of the world so far removed from active volcanoes. Recent Russian exploration has discovered that the supposed Tienshan volcano is merely a solfatara or an ignited coalfield. Among the observations of officers appointed by the Emperor Chien-lung to examine the newly subjugated territory in reference to these "fire-fields," there are several to the following

effect:—"Three days travel to the East of Okishu and to the South of the hill at Palikeh there are several fire-fields. The ground is a red color, and a number of variegated stones are piled upon each other in the neighbourhood, from the middle of which flames upwards of a foot in height are emitted. They are alternately extinguished and lighted up, while the smell is so strong as to render a near approach to the place impossible. For a distance of about 10 *li* not a blade of grass, not an inch of wood, nor a drop of water can be seen. From the peculiar smell of the fire thus raised it is imagined that the soil must be strongly impregnated with sulphur."

The same work represents earthquakes as so common in Eastern Turkestan and the desert, that to the inhabitants "they are not considered strong; four or five occur every year; even when violent, they merely cause the doors and windows to rattle, but, on account of the firm and coherent character of the soil and the thick walls and light roofs in common use, the houses are never thrown down."†

A recent English traveller‡ makes a similar statement respecting Central-Asian earthquakes generally. "At Tashkend they generally average five in a year, but are so slight as not to be noticed by anybody." In that part of the world earthquakes appears to be more frequent at the close of the cold season. In the western portion of the seismic zone, they are of greatest frequency and violence in mountain regions.

Anent the opinion of Mr. Perry, that a maximum of earthquakes is coincident with the mean perigee, I submit the following statistical fragment that escaped the fire referred to. It is partially confirmatory of Professor Milne's observations that cold weather furnishes the maximum of frequency.

List of 738 continental shocks:—

1st month	65	7th month	70
2nd month	82	8th month	70
3rd month	72	9th month	56
4th month	49	10th month	43
5th month	46	11th month	65
6th month	63	12th month	88

† Shanghai Almanac, 1854.

‡ Landsell's Russian Central Asia, 1885.

(The first day of the first month occurs about February 6th, or at the new moon which falls nearest to the point when the sun is in the 15th degree of Aquarius). In their seismic records, the Chinese seldom designate the day of the month (moon) when earthquakes occur. Yet a considerable number may be found; seventy-two cases show twice as many in the first and second as in the third and fourth quarters of the moon's phases; forty-eight in the former period and twenty-four in the latter; the 6th day shows the largest number, 12; none took place on the 2nd, 5th, 13rd and 14th: one occurred on each of the following: 4th, 7th, 17th, 20th, 22nd, 23rd, 24th, 28th, 29th. Hours are rarely given; so far as they go, they show that a large majority are nocturnal.

SUPPLEMENTARY NOTE ON EARTHQUAKES IN CHINA.

DATE.	PLACE.	DIRECTION.	DURATION.	CHARACTER.	AUTHORITY.
1.—March 19th, 5 p.m.	Formosa, S. Cape, N.L. $21^{\circ} 55' - 25^{\circ} 16'$, E.L. $120^{\circ} 15' - 125^{\circ}$.	N. to S.	9"	General oscillation Two shocks, cloudy with rainy aspect ..	J. R. Harding. Foochow Herald. Hongkong papers. Foochow Herald. Foochow Herald.
2.—March 25th, night	Foochow, N.L. $26^{\circ} 02' 24''$, E.L. $119^{\circ} 25'$				
3.—May 27th, 11 a.m.	Formosa	S. to N.	15"	Seven shocks Slight, less so on the coast Rattle severe, with dense fog and sulphurous odour.....	Foochow Herald. Foochow Herald. Foochow Herald. Père Dechevrens. Shenpao. Shenpao. Shenpao.
4.—June 2d, 1 p.m.	Foochow				
5.—July 29th, 9 p.m.	Chungking, N.L. $29^{\circ} 44' 10''$, E.L. $100^{\circ} 42'$				
6.—August 11th, 2 p.m.	Ningpo, N.L. $31^{\circ} 24' 29''$, E.L. $121^{\circ} 32' 02''$ Shanghai				
7.—Sept. 12th, 11.40 p.m.	Wanchow, N.L. $35^{\circ} 25''$, E.L. $120^{\circ} 25' 25''$				
8.—Sept. 22d, midnight	Amoy, N.L. $28^{\circ} 04' 15''$, E.L. $120^{\circ} 09' 37''$		2"	Two slight shocks Two slight shocks Three shocks.....	Native. Amoy Gazette. Shenpao. Foochow Herald. Foochow Herald.
9.—Sept. 23d, 10 p.m.	Ningpo				
10.—Sept. 27th, 9 & 11 p.m.	Foochow				
11.—Oct. 7th	Foochow				
12.—Oct. 14th, 9 p.m.	Tai-yuen, N.L. $37^{\circ} 53' 30''$, E.L. $112^{\circ} 30' 30''$				
13.—Dec. 2d	Shenchow, N.L. $36^{\circ} 06'$, E.L. $115^{\circ} 37'$				
14.—Dec. 9th	Formosa				
	Hongkong	E. to W.			
Dec. 9th, 9.50	Amoy		15"	Slight	Hongkong papers. Amoy Gazette.
Dec. 9th, 10.10	Amoy		26"	Violent	Amoy Gazette. Amoy Gazette.
Dec. 9th, 1.40	Amoy			Milder	Amoy Gazette.
Dec. 9th, later	Amoy			A force	Amoy Gazette.
Dec. 9th, 12.30 p.m.	Foochow			Two shocks each 1'	Foochow Herald.
Dec. 9th, Early a.m.	Foochow			Two slight shocks	Foochow Herald.
Dec. 9th, 10.34 & 10.35	Shanghai	E. to W.		Barely perceptible	T. W. Kingmill.
15.—Dec. 15th, 9 p.m. to a.m.	Kiukiang, N.L. $29^{\circ} 54'$, E.L. $116^{\circ} 04' 30''$			Five shocks	Consul Jamieson. Amoy Gazette.
16.—Dec. 16th	Amoy	S. E. to N. W.		Two shocks, one very severe	
17.—Dec. 12th, night				One slight shock	
18.—Dec. 14th, night		S. to N.		Three shocks	
19.—Dec. 20th, night		S. to N.		Two shocks	