envelop a city in total darkness for thirty-six hours, *eighty miles distant.* On that diagram I have sketched an imaginary picture of the eruption, and eighty miles distant is represented by a little over an inch and a half, where you see the letter B, showing to your mind the relative distance of Batavia from Krakatoa. You can form in your imagination some idea of the great height that the dust cloud ascended: to my mind twice forty would not be too great. Then again we have the ship *Charles Bal*, when *thirty miles distant*, was enveloped at noon-day in pitch darkness through the mud-fall. Furthermore, as Lockyer says, the sound, the least part of the affair, was heard over an area of 4000 miles in diameter, viz. in Ceylon to the north-west, at Saigon to the north, and throughout North Australia to the south-east. In the last quarter the reports were at intervals of fifteen minutes, and sounded like ship-guns, but as the hearers were from 150 to 200 miles from the coast, such cause could not be assigned. All that can be said is that it is beyond the human mind to conceive of such gigantic forces, and therefore absurd to throw doubt on the result; by which I mean that if the laws of refraction show that the substance, whatever it may be, that causes the red glow, is at an altitude of forty or sixty miles, it is ridiculous to doubt that result, when we cannot conceive the magnitude of the power that operated.

It was not only one eruption that took place, but several, during the 26th, the following night, and up to 11.15 a.m. of the 27th, about which time the grand finale is supposed to have taken place. These eruptions followed each other in rapid succession, and are thought to have been caused by the rapid conversion into steam of vast quantities of water that found admittance into the bowels of the earth. Later on the influx of water was too much, and the result was that a tremendous power was generated, so much so as to cause the north part of the island to be blown away, and fall eight miles to the north, forming what is now called Steers Island. This was followed by a still greater eruption, when it is thought that the north-east portion was blown clean away, passing over Long Island, and fell at a distance of seven miles, forming what is now known as Calmeyer Island. These suppositions are almost proved to be facts, from the Marine Survey of the Straits just concluded, from which it will be seen that the bottom surrounding these new islands has not risen, which would most naturally have been the case had they been caused by upheaval, but if anything the bottom shows a slightly increased depth in the direction of the great pit that now occupies the position that the peak of Krakatoa did the day before. These incidents are cited to show you the awful nature and magnitude of the forces brought into play, as you can the more readily satisfy your minds as to the great height the dust and ash were thrown to.

As I said before, this dust cloud may probably be denser in some places than others, owing that fact to the relative period of time that elapsed between each eruption; where it is dense we may assume that they followed each other rapidly, and where it is less dense the interval of time was greater. For you must remember that it was shown to you that the cloud apparently moves to the westward, or that the earth moves from beneath the cloud, at the rate of 87 miles per hour, so that during each hour of the eruption there was a long streak of smoke and dust being formed. These densest parts were no doubt the cause of the coloured suns, and as some observers state, "the sun appeared to shine with diminished strength," others "that it was rayless and giving no heat," so we may look upon that dust cloud as playing the part of a great screen, shutting off some of the heat of the sun from us. In these southern latitudes we have experienced those brilliant sunsets for over seven months, and I have no hesitation in expressing my opinion that the remarkably cool and wet summer just passed in New Zealand was due to that dust cloud shutting off the sun's heat in a great degree. And I see from the Adelaide report that the mean temperature there during January was over 4½ degrees cooler than the average of the previous twenty-five years, and on only one occasion during that period was it so low, viz. in 1869. At Melbourne also the weather was more like winter than summer, whereas in North and Central Australia, or I may say down to lat. 30° on that continent, the weather was fine, clear, and hot, without rain, giving me the idea that the sun had less power than usual; consequently the north-west monsoon was very feeble, not penetrating far inland, the result being that the interior of Australia has undergone one of the most disastrous droughts on record. But now that, as we may suppose, the equatorial regions of the atmosphere have parted with the greater part of their dust, if not all, the sun has regained his usual power, and the north-west monsoon its usual strength, penetrating the heart of Australia with refreshing rains and thunderstorms. So we have here an instance of a most terrific phenomenon that not only brought death and destruction to thousands at the time, but that indirectly caused the death of thousands and thousands of cattle and sheep through drought, and it would be most interesting and instructive to learn whether or not such consequences were experienced in other parts of the Southern Hemisphere at least.

It would be beyond the province of this paper, and in fact too late to-night, to enter on a history of the tidal and atmospheric waves that resulted from this eruption, but I will state two facts to finally clinch your mind of its magnitude. When the earth opened her mouth and swallowed that vast quantity of water, the down-rush that accompanied the closing-in of the surrounding crust was so much as to produce a tidal wave that passed and repassed twice, I believe, round the globe. The other fact is, that the tremendous explosion that accompanied the final eruption produced such a vacuum as to cause atmospheric waves to start, and which traversed and retraversed the earth to the antipodes of Krakatoa no less than four times.

Some astronomers have thought that the whole phenomenon may be accounted for by supposing the earth to be passing through a dense meteoric track. To my mind, however, the greatest difficulties brought to bear against the volcanic theory are child's play when compared with the possibility of about 10,000,000,000 to one of a meteoric track so formed as to have its path, either at aphelion or perihelion, so remarkably coincident with that of the earth as to keep company with her for seven or eight months. Besides, were it either meteoric or cosmic dust, it would be seen all over the earth at the same time, and would be visible all night.

No; the only extra-terrestrial argument that would bear any investigation is that of its belonging to the phenomenon of the zodiacal light, which argument, I believe, was adopted at first by my friend Charles Todd of Adelaide; but, as time goes on and more information is gathered, the volcanic theory, I believe, will be finally adopted.

THE THEORY OF THE WINTER RAINS OF NORTHERN INDIA[1]

AT first sight, the occurrence of rain in Northern India at the season when the north-east or winter monsoon is at its height seems to present a meteorological paradox. The well-known theory of the winter monsoon is that at that season the barometer stands highest in North-Western India where the air is cold and dry, and lowest in the neighbourhood of the equator where it is warm and moist; and therefore, in accordance with elementary mechanical laws, the wind blows from the former to the latter. But the precipitation of rain requires that the air should have an ascending movement, and this can take place only over a region of low barometer, towards which, therefore, the winds are pouring in. Hitherto no one has attempted the reconciliation of these apparently discrepant conditions.

Since the establishment of a Meteorological Department under the Government of India has rendered it possible to study the weather of India as a whole from day to day, it has been my practice to investigate every case of cold weather rainfall in Northern India, amounting generally to three or four in each year, and although many important points still remain for elucidation, it is now at least possible to clear up many of the difficulties of the problem, and to reconcile the apparent inconsistencies.

The charts which accompany the paper show the distribution of atmospheric pressure and the prevalent winds in the four months of the cold weather. They exhibit many features in common. The region of highest barometer is in the Punjab and the Indus Valley, and from this an axis or ridge of high pressure extends across Rajputana and Central India, having a trough of slightly lower pressure in the Gangetic plain and the Northern Punjab on the one hand, and a much lower pressure in the peninsula on the other. The winter monsoon blows around this region of high pressure in an anticyclonic curve, *i.e.* in the direction of the watch-hands, but in the Punjab and the Gangetic plain there is but little movement of the air, the average rate

[1] Abstract of a paper read before the Asiatic Society of Bengal on March 5, 1884, by H. F. Blanford, F.R.S., President of the Society.

being less than two miles an hour, and calms constitute about one-third of the observations. Also it is shown, by the barometric registers of the Himalayan hill-stations, that that distribution of pressure which, on the plains, causes the north-east monsoon, does not exist and is even slightly reversed at an elevation of 7000 feet.

Hence, in Northern India, the state of things which produces the winter monsoon is restricted to a small height, and is then only an average and not a permanent condition; and that which chiefly characterises the atmosphere is its stillness, a condition in which any local action, small and feeble as it may be at first, may eventually set up a disturbance such as to revolutionise the existing conditions.

The cold weather rainfall is always the result of a local fall of the barometer, the formation of a barometric depression, which generally appears first in the Punjab or Western Rajputana, and then moves eastwards. Towards and around this depression the winds blow cyclonically (*i.e.* against the direction of the clock-hands), and the winds from the south, coming up charged with vapour which they have collected from the warmer land surface of the peninsula and sometimes from the sea, discharge this as rain chiefly to the east and north of the barometric minimum, where they form an ascending current.

Thus in the cold weather, rain generally begins in the Punjab and later on extends to the North-Western Provinces, Behar, and sometimes to Bengal. As the disturbance travels eastwards, it is followed up by a wave of high barometric pressure, and cool north-west winds, which usually last for a few days after the rain has cleared off.

The crucial point of the problem of the cold weather rains is, then, how to account for the formation of these occasional barometric depressions in a region where the barometer is generally high at this season. It has been suggested by one writer that they travel to us from the west across Afghanistan. This, however, can be only a guess in the dark, for, at the time it was made, there were no observatories to the west of India nearer than Bushire, at the top of the Persian Gulf. There is one now at Quetta, and I have examined the registers of this observatory to see if they give any support to the idea, and find that, with the exception of two doubtful instances, they do not. I conclude therefore that in most cases, if not in all, these disturbances originate in India, and their cause is to be sought for in the meteorological conditions of Northern India itself. In some instances they make their first appearance in Rajputana or Central India, and there can then be no question whatever of their purely local origin.

Now the region over which the winter rains are more or less regularly recurrent coincides with that in which the relative humidity of the air at this season, instead of diminishing towards the interior of the country, increases with the increasing distance from the coast. In any month between March and December, as we proceed from the coast of Bengal towards the Upper Provinces, the air becomes drier and drier, not only as containing an absolutely smaller quantity of water vapour, but also, in most months, in virtue of its increased capacity for taking up vapour, owing to its higher temperature. But from December to March the dryness increases inland only as far as Behar. Beyond this, although the quantity of vapour in the air remains very nearly the same or even undergoes a slight diminution, in virtue of the increasing cold there is an approach to that temperature at which this small quantity of vapour would begin to condense, forming cloud or fog; and it is in the Punjab that, in this sense, the air is most damp. The result is that which our registers show to be the case, viz. that from December to March it is also the most cloudy province. This seems to depend very much on the stillness of the air. The vapour that is always being given off from the earth's surface diffuses gradually upwards in the still atmosphere, and soon reaches such an elevation that it begins to condense as cloud. When once a moderately thick bank of cloud is thus formed, the equilibrium of the atmosphere is speedily disturbed. It is well known as a fact from Glaisher's balloon observations, and is also a consequence of the dynamic theory of heat, that the vertical decrease of temperature in a cloud-laden atmosphere is much slower (about one-third) than that in a clear atmosphere. This initial disturbance will suffice then to cause an indraught of air from around, an ascending current is set up, the barometer falls; warm, vapour-laden winds pour in from the south, and we have all the conditions of the winter rains.

If this view be just, the stillness of the atmosphere combined with the presence of a moderate evaporation must be accepted as the condition which primarily determines the formation of barometric minima and the winter rains of Northern India. And this stillness is obviously due to the existence of the lofty mountain ranges which surround Northern India, leaving free access to the plains open only to the south.

Were the Himalayan chain absent and replaced by an unbroken plain stretching up to the Gobi Desert, it is probable that the winter rains of Northern India would cease; any local evaporation in the Punjab and Gangetic valley would be swept away by strong, dry, north-east winds blowing from the seat of high pressure, which, in the winter months, lies in Central Asia, and instead of the mild weather and gentle breezes which now prevail at that season on the Arabian Sea, it would be the theatre of a boisterous and even stormy monsoon, such as is its local equivalent of the China Seas.

SCIENTIFIC SERIALS

Bulletin de l'Académie des Sciences de St. Pétersbourg, vol. xxix. No. 2.—On a new comet, by O. Struve. Its elements, calculated by Herr Seyboth, are:—T = 1884, January 23·225 average time of Pulkowa; $\pi = 92° \, 19' \, 39''$; $☊ = 253° \, 22' \, 52''$; $i = 74° \, 21' \, 56''$; $\omega = 198° \, 56' \, 47''$; $q = 9·87922$. Dr. Struve considers it as identical with the comet of 1812, calculated by Encke, and adds a note, by Herm. Struve, about the sudden increase of its light on September 19 to 22.—A report on M. Backlund's memoir on the motion of the comet of Encke from 1871 to 1881, by O. Struve.—On petrified wood from Ryazan, by Prof. Mercklin; it is like *Cupressinoxylon erraticum*.—Observations on some propositions relative to the numerical function $E(x)$, by V. Bouniakovsky (third paper).—Remarks on Ginakîrti's "Kampakakathanâkaka," translated by A. Weber, by Otto Böhtlingk.—On the contact of inverse figures with the polar reciprocals of the directing figures, by J. S. and M. N. Vanecek.—Note on wollastonite, by N. Kokscharow.—Telephonic phenomena in the heart produced by the irritation of *nervus vagus*, by N. Wedenski.—On the use of the telephone for the measurement of temperature, by R. Lenz.—On terrestrial currents compared with magnetic variations, by H. Wild.—On the variability of the light of Y Cygni, by Ed. Lindemann. The observations were made in 1881 to 1883, and the magnitude varied from 6·8 to 10·4, showing an annual periodicity. The star changed its colour, as also its shape, becoming sometimes more nebulous, and the changes could scarcely be explained by mere conditions of observations.—Determination of the parallax of α Tauri, by Otto Struve. Its value, deduced from observations made in 1850 to 1857, is $0''·516$, with a probable error of $0''·057$.—On some arithmetical consequences of the formulæ for the theory of elliptical functions, by Ch. Hermite.—Note on the discovery of kalait in Russia, by N. Kokscharow.—Studies on milk (second and third papers), by Heinrich Struve; being a series of analyses of cows' and human milk, which bring the author to the conclusion that there are two kinds of caseine, the α-caseine and the β-caseine.—On the atmospheric waves produced by the Krakatoa eruption, by M. Rykatcheff.

Verhandlungen des Naturhistorischen Vereins der preussischen Rheinlande und Westfalens, fortieth year, 1883.—Contributions to the knowledge of the igneous rocks in the Carboniferous hills and New Red Conglomerates between the Saar and the Rhine, by H. Laspeyres.—On the trachyte of Hohenburg near Bonn, by the same author.—A study of the Devonian formations between the Roer and Vicht Rivers, by E. Holzappel.—Remarks on the loess of the Lahn Valley, by F. F. von Dücker.—Tertiary shingles of marine origin on the slate hills of Nassau and Ems, by the same author.—An account of some living American reptiles, spiders, and insects found at Uerdingen amongst the dye-woods imported for the Crefeld silk dyeworks, by F. Stollwerck.—Report on the prehistoric remains of the Sieg Valley, by Dr. M. Schenck.—On the development of the mining and smelting industries in the Sieg district, by H. Gerlach.—Remarks on some monstrosities and aberrations in the colour of the mammals of Westphalia, by Dr. H. Landois.—On the greenstone of the Upper Ruhr Valley and its association with the slates of the Lenne district, by A. Schenck, jun.—A description of some archæological remains from the Vlotho district, Weser Valley, by H. D'Oench.—A contribution to the study of the flora of the Rhenish Province, by M. Melsheimer.—A survey of the geological relations in the French Ardennes, by Prof. von