and important questions. The fact that the eruptions have been almost simultaneous suggests that the orifices are situated on the same fissure, but it is, of course, possible that they may indicate a zone rather than a line of weakness in the earth's crust, and so may not have tapped precisely the same source of supply. Again, both eruptions have been preceded by a long pause, during which a column of heated material may have been kept standing for several years in the "neck" of the volcanoes. If so that would be very favourable to magmatic differentiation, and this might be revealed on chemical and microscopic examination of the materials discharged during the successive stages of the eruptions. Dr. Tempest Anderson's wide experience as a traveller, especially in volcanic districts, with his skill as a photographer, and Dr. Flett's intimate knowledge of all sides of petrology, will ensure, by their working in combination, that nothing will be missed, and important accessions be made to our knowledge of vulcanology. The shortness of the time before starting is the main difficulty, but as the enterprise is said to be favourably regarded by the Colonial Office and the officers of the Royal Society, and is heartily backed by several London geologists, technical difficulties should not prove insuperable.

There are various signs that the eruptions in the West Indies are connected with the occurrence of other terrestrial and cosmic phenomena. A report in the *Daily Mail* states that the mineral spring waters at Teplitz, Bohemia, turned brown suddenly last week. A similar phenomenon was observed before the great earthquake at Lisbon in 1755, and a repetition of the disaster is feared.

Telegraphic communication between Karachi and the rest of India has been interrupted for four days by the occurrence of the most severe and destructive storm ever known in Sind. Upwards of 40 miles of the Sind Railway have been washed away, bridges and embankments have disappeared, and the telegraph line for 50 miles either completely vanished or hopelessly dismantled.

There has been a great storm in the United States. A telegram from Goliad, Texas, states that on May 18, at 3.45 p.m., a tornado, preceded by heavy hail, swept over the town and caused great destruction. The storm lasted only five minutes. It came from the south-east without warning, and travelled as far as Kentucky, traversing four States.

Also from the United States news has been received of a great mining disaster. On May 19, at 7.30 a.m., the Fraterville and Thistle coal mines at Coalcreek, Tennessee, exploded, causing the death of about three hundred men at work in them. Rescue parties have been unable to penetrate far into the mines on account of stifling smoke and gas and extreme heat.

Mr. W. Eddy, of New York, reports that on May 15 a slight earth tremor affected three of his seismographs, the wave coming from the south-east.

All these disturbances are possibly related to a common cause, as suggested by Sir Norman Lockyer in the following letter, which appeared in Monday's *Times* :—

THE WEST INDIAN ERUPTIONS AND SOLAR ENERGY.

SIR,—In 1883, in connection with the eruption of Krakatoa, you were good enough to allow me to appeal through your quickly and widely circulated columns for early information to enable me to test an idea connected with the spread of the glorious sunsets round the world which followed the event.

Because the terrible catastrophes in Martinique and St. Vincent occurred at a well-defined sun-spot *minimum* I was led to inquire whether similar coincidences were to be traced in the past. I did not know then, but I know now, that Wolf, exactly half a century ago, had suggested a connection between solar and seismic activity ; in his time, however, the record of solar changes was short and imperfect.

In my own inquiry I have used our most recently compiled tables, which are now complete for the last seventy years, and I have only considered seismic disturbances within that period. I find it beyond question that the most disastrous volcanic eruptions and earthquakes generally occur, like the rain pulses in India, round the dates of the sun-spot *maximum* and *minimum*. More than this, the 35-year solar period established by Dr. Lockyer, which corresponds approximately with Bruckner's meteorological cycle, can also be obviously traced, so that, indeed, the intensification of the phenomena at the *minimum* of 1867 is now being repeated.

In 1867, Mauna Loa, South America, Formosa, Vesuvius were among the regions involved ; in the West Indies it was the turn of St. Thomas. The many announcements of earthquakes in the present year before the catastrophe of St. Pierre will be in the recollection of everybody.

In the *maximum* in 1871-72, to name only West Indian stations, Martinique first and then St. Vincent followed suit ; in the next *maximum*, in 1883, came Krakatoa.

At Tokio, in a country where the most perfect seismological observatories exist, we find that at times near both sun-spot *maxima* and *minima* the greatest number of disturbances have been recorded.

Very fortunately, the magnificent work of the Indian Meteorological Department enables us to associate the solar changes with pressures in the tropics, and obviously these pressures have to be taken into account and carefully studied.

This, Sir, brings me to the point of this letter, which is, through your kindness, to ask from meteorological observers in the West Indies and the surrounding regions the favour of copies of their barometrical readings, showing the departures from the local means for the two months preceding the eruption at St. Pierre. In this way one or two years may be saved in getting at the facts.

I am, Sir, your obedient servant,

NORMAN LOCKYER.

Solar Physics Observatory, May 17.

MOUNTAIN MASSES AND LATITUDE DETERMINATIONS.[1]

WHEN we take a comprehensive view of the information that has been collected in order to determine the mean figure of the earth, we must acknowledge the important part that has been played by a long succession of Indian geodesists. For practically a century, with greater or less vigour, according to the political conditions prevailing at the time, continuous measurements have been carried on, with the result that we have at least eight meridional and four longitudinal arcs available for the general discussion. The differences of latitude extend from roughly 9° to 20° north, and include the determination of the astronomical latitude of some 150 stations, while the amplitude of the longitudinal arcs embraces nearly 25°, necessitating the investigation of fifty differences of longitude. The vigour displayed is the more curious since it must have been anticipated that the results would be affected with systematic error, as the deflection of the plumb-line would be materially influenced by local circumstances. Not only are the evident masses of the Himalayan range and the Tibetan plateau exercising an effect, which may, perhaps, be allowed for satisfactorily on the assumption of a uniform distribution of density in the strata below the surface, but the presence of the Indian Ocean on two sides of the peninsula, with its varying and uncertain depths, emphasises the difficulties of adjustment and compensation.

Since, however, in order to obtain the full value of the admirable work that has been accomplished in India, it is necessary to eliminate the effect of local attraction, various attempts have been made by different authorities, with, it must be admitted, only partial success. It is a matter of ancient, but of interesting, history to recall the suggestions and the controversy between Archdeacon Pratt and the late Astronomer Royal, the views of neither authority now being acceptable in their entirety, though

[1] "The Attractions of the Himalaya Mountains upon the Plumb-line in India. Considerations of recent Data." By Major S. G. Burrard, Royal Engineers, Superintendent Trigonometrical Surveys. Pp. vii + 115. (Dehra Dun, 1901).

Airy, guided by the insufficiency of the Archdeacon's results to explain the numerical discrepancies, was fully justified in asserting that the magnitudes of attractions computed on the theory of gravitation would be too great. He was less happy in the reason assigned for this conclusion. Airy seems to have considered that the Himalaya Mountains were floating in a sea of dense lava, and that the bases of the mountains displaced a quantity of denser material, much in the same way that an iceberg displaces the water of the ocean on which it floats. The more legitimate explanation seems to be that the elevations are composed largely of an expansion of the matter in the immediately subjacent strata of the earth's crust, the masses above and below being mutually interdependent; where high elevations exist, therefore, the strata below are deficient in density, having parted with some of their contents. At low elevations the density is normal, since there is no appreciable upheaval of matter, while under the sea there is a contraction of matter and consequently an increase of density. These views have generally been supported by the pendulum experiments of Von Sterneck in the neighbourhood of the Alps and the still more recent measurements carried out near Kolberg in connection with the German geodetic operations. The misfortune, however, in all these inquiries is that it is impossible to detect the distance below the surface at which the excess or defect of matter may exist, and, therefore, the intimate connection between the unevenness in the earth's crust and the unequal distribution of subjacent material is not clearly demonstrated.

But in India, the very wealth of observation spread over a district so wide introduces new difficulties and taxes ingenuity to the utmost. The latest authority to struggle with the problem is Major S. G. Burrard, already well known to geodesists for the skill with which he unravelled the perplexities connected with the collimation of the transit instruments used in the longitude inquiries, and later for the very successful determination of the longitude of Madras, in which the circuit errors are reduced to a minimum. One therefore watches his attempt to deal with this old problem with a great deal of interest, and is inclined to treat his deductions with considerable respect.

The particular point at issue may be stated thus: How is the astronomical zenith situated with regard to the geodetic zenith at the principal station for reference of latitude in India? This station is Kalianpur, the astronomical latitude of which, after complete discussion, had been settled at 24° 7′ 11″·10, and from this quantity, by the aid of observed azimuths and the constants of Clarke's spheroid, the geodetic latitudes of all the fundamental stations have been computed. An examination of the results shows that the mean excess of the astronomical over the geodetic values of latitude is −2″·0, or, put in another way, it is shown that of the 148 astronomical latitudes available for geodetic investigation, there are 90 cases of negative excess to 58 of positive. It appeared, therefore, to the late General Walker, and his conclusion has been generally accepted, that the astronomical latitude of Kalianpur was too great by 2″, and that the plumb-line was not deflected to the north, under the influence of the Himalaya Mountains, but was in reality deflected to the south. With the view of settling the question, he recommended that the latitude of a number of subsidiary stations within a moderate distance of the central station should be derived, and the mean latitude be used for the central station, since it might be assumed that such a final result would be more free from the effects of deflection than the latitude of any single point. Such a view regards the deflection as arising from local causes operative over a small area, but Sir David Gill has since pointed out the very obvious objection that if local attraction is persistent in one direction over large continuous areas, group observations such as those recommended would be insufficient to eliminate the effects, and it is not the least important part of Major Burrard's investigation to show that the latent causes of disturbances must be sought over very extended areas.

This work of latitude determination has now been completed under the superintendence of Captain L. Conyngham, and Kalianpur has been surrounded by a chain of stations, of which four are situated at an average distance of nine miles and four at an average distance of thirty-five, and the unexpected result of the discussion is to show that local attraction causes a northerly deflection of the plumb-line to the amount of 0″·60, thus differing by 2″·60 from the value found by General Walker drawn from the whole of the Indian observations. The results in the prime vertical are not less contradictory, and in the following table is exhibited the amount of deflection in the two planes, at each of the group of latitude stations around Kalianpur, situated within the extreme parallels 23° 36′ to 24° 38′:—

	Deflection in the Meridian.		Deflection in the Prime Vertical.	
	The Group System.	Whole of India System.	The Group System.	Whole of India System.
	″	″	″	″
Daiadhari	+1·01 S.	+3·61 S.	+2·13 W.	+5·35 W.
Surantal	+0·82 S.	+3·42 S.	+3·64 W.	+6·86 W.
Sironj	+1·69 S.	+4·29 S.	+2·54 W.	+5·76 W.
Bhaorasa	+1·17 S.	+3·77 S.	+0·22 W.	+3·44 W.
Kalianpur	−0·60 N.	+2·00 S.	−0·22 E.	+3·00 W.
Losalli	−1·02 N.	+1·58 S.	−6·38 E.	−3·16 E.
Tinsia	+0·98 S.	+3·58 S.	—	—
Salot	—	—	−4·49 E.	−1·27 E.
Kamkhera	−2·15 N.	+0·45 S.	+0·04 W.	+3·26 W.
Ahmadpur	−2·49 N.	+0·11 S.	+2·27 W.	+5·49 W.

The stations in this table proceed regularly from the north towards the south, and, confining attention solely to the deflections in the plane of the meridian, it is clear that north of Kalianpur we get a southerly deflection, while on the southern side the plumb-line tends to the north. Clearly, then, the Himalaya chain, which has been so frequently invoked to explain inconvenient discrepancies, will not avail here. And the insufficiency of such a hypothesis is still more clearly shown if the deflections be examined at stations nearer to the mountains. At Dehra Dun, the most northerly, in latitude 30° 19′, the deflection is 38″; in latitude 29° 31′, the deflection is reduced to 7″, and disappears entirely in latitude 27° 51; while south of Kalianpur we meet with northerly deflections diminishing in amount as Cape Comorin is approached. Major Burrard clearly puts the dilemma thus: "If Himalayan attraction is capable of producing a deflection of 38″ at Dehra Dun, its effects must be felt at Cape Comorin; on the other hand, if Himalayan attraction exercises no effect on plumb-lines south of latitude 29° 31′, it cannot produce a deflection of 38″ at Dehra Dun."

We cannot follow Major Burrard through the various steps by which he seeks to remove the anomalous results, but his method is as exhaustive in theory as it is laborious in practice. He considers the effect of the surrounding ocean on the derived longitudes, and shows that these results stubbornly enforce the necessity of admitting the entire compensation of the ocean. He also asks whether it is possible to introduce any admissible alteration in the dimensions and ellipticity of Clarke's spheroid, and the answer is not less certain. He finds that Clarke's major axis is the most suitable for the Indian longitude arcs, and that, as concerns latitude, while one belt of negative maxima requires an ellipticity greater than 1/289, the large sub-Himalayan deflections demand an ellipticity smaller than 1/311. He therefore concludes that the accepted spheroid is not a source of serious error, and that the Indian observed latitudes favour the Clarke spheroid.

Finally, the author is driven to the conclusion that the undiscovered cause of disturbance is traceable to a great invisible chain of excessive density, traversing India from Balasore, near the mouth of the Hooghly, to Jodhpur in Rajputana, and underlying Mandla and Bhopal, or roughly running parallel with the Himalayan chain. This hypothesis is supported by the observation or detection of the opposite effects on either side of the hidden chain. Between the parallels 24° and 26°, the plumb-lines are deflected southwards, while between the parallels 21° and 18°, the deflections are north and large. This view is further confirmed by the arc of longitude between Amritsur and Mooltan, for the plumb-line at these stations is deflected inwards towards the low-lying alluvium and away from the mountain masses.

The author gives a table in which is shown the amount of deflection due to the Himalayas, to the Tibetan plateau and to the underground chain, and the algebraical sum of these three effects agrees very closely with the observed discrepancies throughout the whole range of latitude, from 30° 19′ in the north to 8° 9′ at the southern end of the arc. It is assumed in this calculation that the northern and southern slopes of the underground chain are inclined at the same angle to the vertical—a somewhat improbable hypothesis, as the author is aware—but it seems not unlikely that further discussion will disclose the contour of this subterranean chain. The particular claim that Major Burrard has on our gratitude is that he sweeps away the accidental and local attractions that have too frequently been put forward to explain isolated discordant instances, and substitutes one general central cause, which can be confirmed or displaced by further investigation.

SCHOOLS AND SCHOLARSHIPS.

THE receipt of a copy of the new issue of "The School Calendar" (London: Whittaker and Co.) suggested the idea that it would be useful and interesting to extract some information from its pages as to the present position of science at the older universities in regard to the awards of scholarships. And it seemed all the better worth while to attempt this because such statistics as have previously come under our notice distinctly suggest that science is now doing a good deal more for the colleges as a whole by helping to maintain their overflowing numbers, than the colleges do for science in distributing their scholarship funds.

Everyone who is interested in this subject knows very well that a generation or so ago the colleges at Oxford and Cambridge did much to promote the teaching of science in schools, and especially in certain schools, by offering science scholarships in numbers that, for the time being, were not only sufficient, but liberal, and that the results of this policy have been beneficial alike to the colleges and to the students of science who were thus attracted to the universities. This action has, in fact, been so successful that at Cambridge the science tripos is, if not the largest, at any rate substantially equal to its older rivals in numbers, and also in the quality of its members, as is shown by the army of able teachers and investigators which the university has produced during the last thirty years or so.

The experiment made in the nineteenth century then has certainly been a considerable success; it has encouraged many able students, stimulated the science work of schools, and extended the field of usefulness of the universities. But it is a long while since the experiment was begun, and perhaps the time has come to ask whether all is now well; whether the methods of selecting science scholars are satisfactory to the colleges and fair to the candidates, whether the examinations secure a sufficiently good standard in science without tempting the candidates to specialise unduly; whether this work, which was, we believe, initiated by some of the colleges only, is now being helped on by all; and, finally, whether the scholarships offered to those who desire to read in science at the universities are reasonably equal to those offered to students in classics and mathematics.

The little book before us does not afford answers to all these questions, but it contains a great mass of useful information, and within its pages will be found full details concerning the various scholarships that are to be awarded at Oxford and Cambridge during the current year. These, however, we are sorry to add, do not afford very encouraging reading.

Thus we find from the "School Calendar" that at Oxford no less than ten colleges out of twenty offer no scholarships or exhibitions for science at all, and that of the other ten, one important college, which disposes about twenty-eight scholarships and exhibitions, without counting those reserved for students of divinity, only encourages science to the very modest extent of dividing two scholarships between candidates in classics, mathematics, history and science, whilst the remainder are reserved for classics and mathematics. Some of these scholarships, doubtless, are on special foundations, but there are twelve which appear to be under the free control of the college, and all these are allotted to the older branches. At this college about 1700*l.* are to be distributed between classics and mathematics, while classics, mathematics, history and science, will have equal chances, may be, in the distribution of 160*l.*

Again, fourteen Oxford colleges offer their scholarships for definite subjects in advance. These offer fifty-nine scholarships or exhibitions valued at 4217*l.* for classics, ten of the total value of 790*l.* for mathematics, eight of the value of 585*l.* for science, and ten of the value of 670*l.* for history. Whilst if we take the grand total for the twenty colleges, and assume that Magdalen, Jesus and Corpus Christi will together devote as many as four scholarships or exhibitions to science, we find that out of one hundred and forty, or more, scholarships, &c., which have a total value above 10,000*l.*, only twelve, having a value of rather less than 850*l.*, are offered for science subjects. These numbers, it should be added, though near to the truth, are only approximations, as in certain cases the number and value of the scholarships offered are subject to modification. The former figure, however, is below and the latter above the actual result of our computation, and the latter would be smaller did we not make the liberal assumption that Magdalen, Jesus and Corpus Christi will give half as many science scholarships as all the remaining seventeen colleges taken together.

It may be added that several colleges, *e.g.* Lincoln, Keble, Oriel and Pembroke, unless our authority misleads us, offer no encouragement to mathematics, but one of these, Keble, offers a science scholarship.

Turning to Cambridge, we find, as was to be expected, that most of the colleges offer awards for science; still, even at Cambridge four colleges out of seventeen, or nearly 25 per cent., viz. Corpus Christi, Magdalene, Queens' and St. Catherine's, exclude this branch. Owing to the Cambridge custom not to allot scholarships to definite subjects in advance, it is impossible to put forward such particulars as are given above for the sister university. But it may be taken that at Cambridge, as a rule, science receives more favourable treatment than at Oxford. Still, even at Cambridge in certain years not long past, as has previously been shown in these columns, the treatment accorded to science has seemed wanting in liberality, as, for example, in December 1898, when, out of one hundred and one scholarships (value 5150*l.*) given by ten colleges, only sixteen (value 745*l.*) were awarded to science candidates.

Returning now for a moment to the "School Calendar," which has afforded us the above information, it seems, so