subject of first-rate importance. It has come out very markedly in help he has more recently given me for the 1/5M map of Asia, a much more difficult question. I should like to emphasize my appreciation of the very great services Mr. Young has rendered. Mr. McCaw's question, whether volcanic change could have affected the source of the Kagera, I am unable to answer. I am not sure whether any competent geologist has been to the source of the Kagera; it is rather east of the parts affected by the great volcanic outburst in the western rift. However, if it is true that Lake Kivu used to be in the Nile system, then clearly the volcanic outburst has affected the source of the Nile very materially, although not at the particular point Mr. McCaw mentioned. In closing, I should like to express my thanks to those who have spoken all too appreciatively of the work we have been trying to do here, and also to call attention to the fact that we are for the first time making a serious attempt to produce a layer-coloured map of Africa upon an adequate scale. We cannot expect to get contours at close intervals because the parts sufficiently well surveyed are very slight; but we have tried to make contours at intervals of 500 metres, and when they are layer-coloured you do get a representation that is beginning to be satisfactory of what is, I think, the most interesting country in the whole world, the lake region and the two rift valleys of Central Africa.

GEOLOGICAL INTERPRETATIONS OF GEODETIC RESULTS: A CRITICAL EXAMINATION OF MR. R. D. OLDHAM'S RECENT TREATISE ON HIMALAYAN STRUCTURE

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THE alluvial plains of the Ganges conceal from our view a deep "trough" that has been formed in the Earth's crust. The "trough" is bounded on the north by the Himalayan Mountains and on the south by an ancient tableland. This "trough" was called by Suess the Himalayan Foredeep; its origin and its relationship to the mountains are among the unsolved problems of geology and geophysics.

For many years the Trigonometrical Survey of India has been taking geodetic observations over both hills and plains: it has determined the direction and the intensity of gravity at numerous places. During its operations its chiefs have frequently had the benefit of consultation with foreign delegates at International Geodetic Conferences, and with successive directors of the Geological Survey of India. The gap between geology and geodesy is, however, difficult to bridge: the students of the two branches of science have been differently trained, and the best hope of future progress lies in personal collaboration.

Mr. R. D. Oldham, F.R.S., has lately published a memoir ('Memoirs, Geological Survey of India,' vol. 42, part 2, 1917) entitled "The Structure of the Himalayas, and of the Gangetic Plain, as elucidated by Geodetic Observations in India."

When a book on Geodesy is written by a professional geologist it starts on its career with the keen interest of geodesists. But Mr. Oldham's treatise will do nothing towards bridging the gap; its attempts to lower the standard of geodetic accuracy will be resented. As a book it is difficult to follow; for though its language is that of positive assertion, its meanings are frequently obscure. Individual sentences may be strongly worded, yet in the aggregate their collective meaning is uncertain.

In his geodetic calculations Mr. Oldham's first step is to discard the Himalaya Mountains of nature and to substitute for them an "Imaginary Range," the dimensions and contour of which he has designed; he says that the method of geodesy is too laborious. He therefore decides to ignore "the complicated contour of the actual Himalayas." He also assumes in his calculations that his imaginary range has an east and west direction, whereas the true Himalaya extend over 7° of latitude.

Mr. Oldham tries to show that his imaginary range is similar to the true Himalaya in its powers of attraction. The safest way of making such a comparison would be to test the attraction of the imaginary mountains *uncompensated* against the attraction of the true mountains *uncompensated*. But this test is not faced; both the imaginary and the true mountains are assumed to be wholly compensated by underlying deficiencies of matter, and the resultant attractions are thus reduced to small quantities. The attraction of a mountain mass causes deflections of the plumb-line, but if the mass be assumed wholly compensated by underlying deficiencies of matter, its positive attraction will become nullified by the negative attraction, and the deflections will tend to vanish. The deflection of the plumb-line caused at the station of Kaliana by the positive attraction of the true Himalaya is 58″; that caused by the imaginary range is 6″. The discrepancy is no less than 52″, but by taking compensation into account, Mr. Oldham reduces the Himalayan effect from 58″ to 3″, and the effect of his imaginary range from 6″ to 2″ (p. 42). He then compares 3″ with 2″ and argues that a discrepancy of 1″ is admissible.

If we are dealing with a large deflection such as 58″, a discrepancy of 1″ denotes an error less than 2 per cent. But when a large deflection has been reduced by compensation to 3″ a discrepancy of 1″ denotes an error of 33 per cent. Mr. Oldham states that the attraction of the imaginary range (compensated) exceeds that of the true range at all stations, but there are mistakes in his computations (Table 5). At Lambatach in the mountains the effect of the imaginary range (compensated) is 55 per cent. *larger* than that of the true range: whilst at Kaliana, 41 miles distant from the foot of the mountains, the effect of the imaginary range is 33 per cent. *smaller* than that of the true range; errors such as these prove that the imaginary range is not suitable for geodetic investigations.

It is true that when Mr. Oldham first introduces his imaginary range (p. 36) he excuses it on the grounds that it is intended for the preliminary stages and not for the final calculations of the investigation. But he fails to adhere to this stipulation: at the end of his book he arrives at final and positive conclusions concerning the compensation of the Himalaya Mountains (pp. 112, 114), and he claims to have discovered the form of the underground floor of the whole Gangetic trough (p. 119); these conclusions are all based on the imaginary range.

We use the word "trough" for want of a better. The word conveys the idea of a long rock hollow filled with loose alluvium. But at moderate depths alluvium becomes compacted into solid rock: and at greater depths it may become metamorphosed. Mr. Oldham describes the Gangetic "trough" as though it were a simple depression in the rock-surface filled with alluvium, and as though the alluvium were 16,000 feet deep (pp. 7, 8 *et seq.*). This value of the depth is obtained from Middlemiss's measurements of exposed strata at the foot of the Himalaya in Kumaun, north-east of Delhi ('Geological Survey of India,' vol. 24, p. 29). But Middlemiss shows that these strata are built up of the following thicknesses:—

	Feet.
Siwalik conglomerate	3000
Sand-rock	8000
Sandstone	6000

Thus the trough is not a rock-basin containing loose alluvium; it is a basin constructed of ancient rocks in which Tertiary rocks have been consolidated. The dividing line between the northern wall and its solid contents can be discovered only by a geologist. Geodesists have used the word "trough" to denote the crustal zone throughout which the rock is of lower density than normal; and they take the depth of the trough to be the depth to which deficiency of density extends, independently of the kind or age of the rocks involved.

We have now to consider this problem: If the sides and floor of a trough have been formed of ancient rocks, and if its contents consist of Tertiary rocks, can a pendulum be utilized to determine the depth of the lowest Tertiary rocks?

If at any place a pendulum is observed to be swinging at a slower rate than normal, a deficiency of rock in the underlying crust is indicated; whereas if a pendulum is observed to oscillate rapidly, the inference is warranted that the underlying crust is unusually dense. These variations in the rate of swing at different places signify variations in the force of gravity, and constitute what are known as local "gravity anomalies." Wherever a gravity anomaly is observed to be negative, the crust is abnormally light, and wherever a gravity anomaly is positive the crust is dense.

An excess or defect of matter may be near the surface of the crust, or it may be hidden at a great depth. Geodesists have met with difficulties in dealing with this problem of depth: they can prove the existence of an excess of matter in the crust, but they are unable to determine whether the excess is superficial or deep.* Observations have shown that the density of the crust is different in different regions, and varies from place to place, and that these unceasing variations extend downwards to great depths (perhaps 70 miles).

If a pendulum station is situated above the light Tertiary rocks of the Gangetic trough, the gravity anomaly will have a tendency to be negative. But the deeper rocks will affect the pendulum also : and if they are unduly light they will *accentuate* the negative tendency, whereas if they are dense, they will *counteract* that tendency. A gravity anomaly is due to both surface and deep-seated rocks, and the difficulty is to disentangle their respective effects. By means of a sounding-line we can discover the depth of water, and by boring we may discover the depth of alluvium, but a pendulum is not a sounding nor a boring instrument, and observations of gravity do not determine depths of sea or alluvium.

I do not contend that a pendulum can never be used to determine the depth of a particular rock. I will give an instance in which I think it might be so utilized. The Mysore Gold Mines are situated in a small patch of heavy rock (Dharwar schist, density 3·00) which is lying in a surface hollow of the Mysore plateau (gneiss, density 2·67). The patch of heavy rock containing the gold is only 4 miles wide; if pendulum observations on the gneiss surrounding the patch give a constant gravity anomaly, and if the anomaly at once becomes larger at stations on the patch, the increase in the intensity of gravity may be fairly attributed to the excessive density of the patch. No complete investigation has yet been made, but Lenox-Conyngham found that the gravity anomaly on the patch was 0·034 greater than at Bangalore (Professional Paper 15, p. 24, Survey of India): he has calculated that this anomaly would denote a depth of about 13,500 feet for the heavy schist of the patch. The gold-mining operations have now reached a depth of 5000 feet. The reason, which would justify us in this case in attributing the increase in the gravity anomaly to the patch, would be that the pendulum stations on and off the patch being so near together (*i.e.* within 2 to 3 miles) the cause of the increase would appear to be local.

The Gangetic alluvium presents a different problem: its area is great and we cannot attribute anomalies to any local cause such as the lightness of alluvium. The geodetic observations have led us to believe that the Earth's crust north of the alluvium is deficient in density to a great depth, and that south of the alluvium the density of the crust is excessive. Under the Himalaya the density of the crust is below normal: south of the trough there is a zone of excessive density known as the "hidden range" (p. 124). The junction of the two different densities occurs in the crust underlying the alluvium.

* See the writer's paper on the Gangetic Trough, *Proc. Royal Society*, A, vol. **91**, pp. 230, 233.

Mr. Oldham considers that the depth of the trough is about 16,000 feet at the northern edge and that it gradually decreases from north to south (pp. 82, 119). All gravity anomalies that can be made to fit this hypothesis he interprets as due to the lightness of alluvium. But anomalies that do not fit he interprets as due to deep-seated rocks *below* the alluvium. On p. 81 he writes of the station Monghyr: "Though situated close to the southern edge of the alluvium it gives a Bouguer anomaly of $-0{\cdot}031$, and a Hayford of $-0{\cdot}024$ dyne, and, as it is difficult to believe that there can be a thickness of over 4000 feet of alluvium under this station, we must fall back on the supposition that the anomaly is due to a more deep-seated deficiency of density. A similar, though smaller defect of density at the station of Sasaram, suggests that in both cases the anomaly may be due to a deep-seated defect of density in the rocks below the alluvium."

The fact that the anomalies at Monghyr and Sasaram have to be rejected as untrustworthy measures of the depth of surface alluvium raises the question, What security is there that other anomalies give reliable measures? There is no security; a gravity anomaly is a measure of the density of the Earth's crust, and not of the uppermost layer only.

If the gravity anomalies at alluvial stations were wholly due to the lightness of surface alluvium, they would everywhere be negative; but at several stations on the alluvium the gravity anomalies are positive. On p. 81, Mr. Oldham writes of two stations on the alluvium at which gravity is in excess: "The high positive anomaly at Kisnapur is evidently the result of a deep-seated excess of density in the rock underlying the alluvium, but its magnitude, and the smaller positive anomaly at Chatra, show that the alluvium cannot have any great thickness, comparable to that in the Gangetic trough, for if there were any great thickness of alluvium the negative effect of the defect in density would more largely neutralize the deep-seated excess of density in one case, and in the other would make the anomaly negative, instead of positive." This argument is incorrect; the positive anomalies merely show that there is an excess of matter in the crust, notwithstanding the surface alluvium; they furnish no evidence as to the depth of alluvium.

The gravity anomaly at Mian Mir on the alluvium is $+0{\cdot}040$ dyne, showing that gravity is in excess. On p. 85, Mr. Oldham writes: "The positive anomaly at Mian Mir shows that the alluvium cannot have any great thickness here." The positive anomaly at Mian Mir merely denotes that the lightness of the surface alluvium is more than counterbalanced by the density of the deeper rock: it is no proof that the alluvium is shallow.

To illustrate the risks of using gravity anomalies as measures of depth, I will refer to Hecker's observations of gravity over the ocean.* When Hecker was vertically over the Tonga Deep he found that the deficiency

* 'Gravity Determinations on the Ocean.' Berlin, 1910. Hecker assumed the ocean to be isostatically compensated.

of gravity was −0·245 dyne. If Hecker had adopted Mr. Oldham's method, he would have deduced the depth of the Tonga Deep to be 13,300 feet; the sounding lead showed that the true depth was 27,800 feet. When Hecker's steamer crossed the Tonga plateau, he found that the gravity anomaly was +0·264 dyne. If then he had used the argument that a positive anomaly denotes shallow depth, he would have concluded that the Tonga plateau could not be far below the surface of the sea. The soundings showed that it was 8800 feet deep.

If an observation for gravity is taken over the ocean, the presence of water can be allowed for as its density is known. But the density of alluvium when compressed and compacted at moderate and great depths is an uncertain quantity. Mr. Oldham has assumed the average density of the Gangetic alluvium from the surface to a depth of 4 miles to be 2·16. The rock-walls of the trough have a density of 2·67, and he assumes that the contents of the deep trough have a density of 20 per cent. less than the rock walls.

General Sorsbie, author of *Geology for Engineers*, estimates that the mean density of the Gangetic deposits, loose and solid, shallow and deep, would be about 2·4. Mr. Hunter has determined the density of exposed Siwalik sandstone at Hurdwar and Mohan, and has found it vary from 2·35 to 2·60, and these specimens were broken from weathered scarps and were possibly less compact than when buried and compressed by the weight of miles of superincumbent strata. He has determined the density of khankar (carbonate of lime) dug from the surface of the alluvial plains, and has found it to average 2·34. Barrell in his investigations of the Strength of the Earth's Crust assumes 2·5 as the density of the deposits of the Nile and the Niger (*Journal of Geology*, 22, p. 43).

There are thus reasons for doubting whether Mr. Oldham's assumption of density = 2·16 is justifiable, and it will be useful to show the effects upon his results if a density-value of 2·4 be substituted.

Station. (See pp. 84 and 90.)	Distance from northern edge of trough in miles.	Depth of alluvium as deduced from gravity anomaly.	
		Density 2·16 according to Oldham.	If density 2·4 be substituted.
Rajpore	0	15,000	30,000
Dehra Dun	2	12,000	24,000
Roorkee	25	13,000	26,000
Nojli	38	12,000	24,000
Pathankot	1	23,000	46,000

Mr. Oldham claims (pp. 91, 119) that his geodetic values of depth *at the northern edge* of the plains agree with the geological value, namely

16,000 feet. My table shows that his claim can be established only if an unduly low density is assumed for the alluvium. The adoption of the density 2·4 produces a great discrepancy between the so-called geodetic and geological values. It must not be supposed that I am putting forward the depths in the last columns of these tables as probably correct: they are, I think, based on more reasonable assumptions than the figures in the third columns, but the lesson they teach is that the method adopted of deducing depths of surface alluvium from gravity anomalies is unreliable. The magnitudes of the quantities in the last column support the view that the negative anomalies over the Gangetic trough are partly due to the attenuation of the rock that is *below* the Tertiary deposits.

On p. 119, Mr. Oldham writes: "We have also found complete confirmation of the geological deduction that the depth of the alluvium along the outer edge of the Himalayas is great, amounting to about 15,000 to 20,000 feet towards the northern boundary of the alluvial plain, figures which are in complete accord with those deduced from the geological examination of the Siwalik hills. This agreement, between the results of two wholly independent and different lines of research, leaves little room for doubt that we have reached a correct interpretation of the underground form of the Gangetic trough from near its northern limit to the southern boundary, and that its maximum depth is about 15,000 to 20,000 feet, possibly more on some sections, probably less on others, but in most cases lying within the limits named."

In this summary Mr. Oldham claims to have discovered the underground form of the Gangetic trough from north to south, and from east to west. The average width of the trough from north to south is 150 miles; its length from east to west is 1000 miles: it occupies an area of 150,000 square miles. Mr. Oldham claims to have interpreted the underground form of this great alluvial area by means of the "agreement between the results of two wholly independent and different lines of research."

Let us consider upon what grounds these claims are based. The geological deduction from exposed strata is that the depth of the trough *at one point* near its northern edge is 16,000 feet (p. 6); there is no geological evidence of depth east or west of this point, and there is no geological evidence anywhere as to the maximum depth of the trough, or as to the distance from the edge at which the maximum depth occurs (p. 8). The geological "line of research" is thus limited to *one point* in a trough 1000 miles long and 150 miles broad. Certain geodetic results can be brought into approximate agreement with this one geological deduction by the adoption of a particular value of surface density.

But even the alleged agreement itself "between the two wholly independent lines of research" is not clearly indicated. The geological deduction was made in the foothills of Kumaun south of the Ganges, where no geodetic stations exist; in the foothills just north of the Ganges there are two geodetic stations, Rajpore and Dehra Dun. In order to confirm Mr. Oldham's geological conjecture that deep alluvium exists under Rajpore and Dehra Dun, negative anomalies were required (p. 107), and these were obtained by the aid of the Imaginary Range (p. 90). But the anomalies as calculated by the Trigonometrical Survey are positive, and this result has placed Mr. Oldham in a predicament (p. 91). He writes that "these stations cannot be used with any degree of safety in determining the form of the trough." Thus the agreement between the different lines of research can only be maintained if two of the most important geodetic results are excluded from the investigation.

From 1866 to 1870 Captain Basevi observed the pendulum at several places in India; he was a careful observer, but in his day no method had been devised of determining the sway of the pendulum stand. When a pendulum is swinging its stand is swayed by it, and this swaying tends to increase the time of the pendulum's oscillation; consequently if no correction is applied, the deduced value of gravity will be too small; the greater the "flexure" of the stand the greater the error in the observed result. For his observations in India Basevi used a heavy braced stand. In 1870 he decided to swing his pendulums at a high altitude in Ladak, and in order to lighten his loads and to facilitate transport he introduced a special light stand. This light stand he used in his observations at the Indian Station of Mian Mir, and he then transported it across the Himalaya Mountains to the station of Moré (height 15,427 feet). In Ladak he died, and it is not known what became of the light pendulum stand.

In 1903 Colonel Lenox-Conyngham commenced his modern series of pendulum observations, and during his first tour he visited four of Basevi's stations. His observations gave larger values of g than Basevi had obtained, the discrepancies varying from 0·027 at Bombay to 0·044 at Madras and to 0·103 at Dehra Dun. These discrepancies were attributed by Lenox-Conyngham to the omission of the "flexure correction" by Basevi (Survey of India, 'Narrative Reports,' 1903–04, para. 139). Other stations of Basevi's were visited in subsequent years. In 1906 Lenox-Conyngham observed at the station of Mian Mir where Basevi had used his special light stand; at this station the discrepancy between the old and the new results was 0·112.

Basevi's pendulum observations have thus been superseded; they served their purpose well, and their supersession is the inevitable fate of all observations which have been rendered obsolete by modern instrumental improvements. His more important stations have been revisited and their results revised. Eighteen of Basevi's stations have not as yet been revisited by modern observers, but in their stead 108 new pendulum stations have been established in India. If it had not been for the war, the station of Moré would have been revisited by a British observer in 1915 or 1916. Commander Alessio of the Filippi expedition (1913) endeavoured to observe the pendulum at Moré, but the attempt had to be made too early in the year and was frustrated by heavy snow.

Basevi's results were included in Helmert's compilations for the International Geodetic Association. After Lenox-Conyngham had completed his observations at Mian Mir, the International Association in 1909 deduced from them a "flexure correction" for Moré. Helmert was constructing a formula that would give the normal value of gravity in any latitude, and the Association wished to show how this formula agreed with observed results. The Association did not intend to convey to geologists the idea that they would now be justified in building far-reaching theories upon the Moré result.

Unfortunately Professor Borrass, who compiled the report, made the mistake of assuming that Basevi's light stand had been used at *two* stations in India, and that its flexure correction had remained *the same* at both places ('Report, 16th International Geodetic Conference,' 1911, p. 236). He thought that the light stand had been used at Dehra Dun as well as at Mian Mir and Moré. Believing that Dehra Dun and Mian Mir should be classed together and finding that the two corrections were accordant, he adopted a mean correction and applied it at Moré. Borrass stated his flexure corrections as follows:—

Deduced at Dehra Dun	+0·103
Deduced at Mian Mir	+0·112
Mean	+0·107 ±0·004

At Dehra Dun the pendulum had been swung on the heavy stand and at Mian Mir on the light one. The agreement between the corrections deduced by Borrass was fortuitous; Borrass's mean value and his probable error being based on misapprehension have thus no weight.

In September 1916 an article by Mr. Oldham on Basevi's pendulum observations appeared in the *Geographical Journal*, in which the author expressed the opinion that the flexure correction for Basevi's results could be estimated. This had already been done, but such an estimate cannot be made with sufficient accuracy. It is a question of the standard of accuracy required. Basevi omitted the flexure correction, and nothing now can raise his results to the modern standard of accuracy. The flexure of Basevi's heavy stand was apt to vary from station to station, and even the modern stand shows variations of flexure sufficiently great to necessitate a redetermination whenever the apparatus is re-erected. As to the behaviour of Basevi's light stand we know but one fact, namely, that his Mian Mir result requires a correction of +0·112.

Mr. Oldham assumes that Basevi's flexure correction was the same at Moré as at Mian Mir. Basevi recorded that at Mian Mir the stand was erected on a "floor of solid paka masonry": at Moré he recorded that the soil was "very loose and sandy." Between Mian Mir and Moré the stand had to be carried on men's backs for hundreds of miles over high mountains and passes: at Moré the stand was exposed to conditions of temperature, pressure, humidity, and wind totally different from those of Mian Mir.

When Mr. Oldham's article appeared I did not understand its purport. No one had been criticizing Basevi, and his pendulum results were being replaced and extended by the modern series. In his memoir Mr. Oldham supplies a reason for his article. He wished to use Basevi's result at Moré in support of a new theory, and he now feels enabled to state (p. 110), that the Moré results having been discredited have been reinstated. As this vague statement may be taken to mean that responsible authorities have reconsidered their opinion about Moré, I may perhaps explain that by "reinstatement" Mr. Oldham means the article he wrote himself in the *Geographical Journal.*

In his memoir (p. 111) Mr. Oldham estimates the anomaly for Moré as —0·434, and compares it with Borrass's result —0·433, published in 1911. He writes: "The two values of anomaly differ by only 0·001 dyne, and we may take it that the deficiency at Moré is not far from 0·43 dyne." It is hardly necessary for me to point out that the agreement of these two results is no evidence of accuracy. These two results are both derived by the same method from the same observation.

Mr. Oldham's new theory seems to be based upon the anomaly at Moré, namely, —0·434; this is certainly a large negative value, but all anomalies at high altitudes, if deduced on Bouguer's hypothesis, have negative values. Bouguer's hypothesis was that mountains were being supported by the rigidity of the crust. It has been recognized for many years that isostatic compensation must be taken into account, and Hayford's method based on the theory of isostasy has now superseded Bouguer's. The substitution of the theory of isostasy for that of extreme rigidity has had the effect of converting the negative anomalies which formerly obtained at high Himalayan altitudes into positive anomalies.

Instead of deducing the Hayford anomaly by clear steps, Mr. Oldham mixes in the same paragraph two geodetic hypotheses (Bouguer and Hayford) and two systems of mountains, the imaginary and the real (p. 111); and then out of this obscurity he draws the conclusion that "in the Central Himalaya compensation is in the excess" (pp. 112, 114). Having produced no evidence, he writes: "It is evident that the defect of composition has disappeared" (p. 112).

One assumption leads to another, and his next step is to assume that as the compensation is in excess at Moré, the whole extensive mountain area of the inner and higher Himalayas must be over-compensated, buoyant and light. (It might be just as fairly assumed that the gravity anomaly observed at Geneva is applicable to the whole area of Pyrenees, Alps and Carpathians.)

Finally, Mr. Oldham proceeds to the further assumptions that as this great Himalayan area is buoyant, it must be rising (p. 115); that the Earth's crust is being uplifted here by its buoyancy, and that owing to its uplift the crust to the south is being tilted downwards and is creating the Gangetic trough (p. 123). In this way his reinstatement of the Moré result has led up to his theory of the origin of the Gangetic trough.

The Trigonometrical Survey of India has benefited in the past from the collaboration of men who were not professional geodesists, notably, Archdeacon Pratt and Osmond Fisher. These distinguished investigators were endeavouring to utilize the geodetic data for unravelling the secrets of Nature. The welcome that was extended to them was awaiting Mr. Oldham; but his attitude towards geodesy has been different. He has considered it admissible to alter scientific data and to create new data from imaginary ranges. In the same table (pp. 77 and 90) he combines true geodetic data with figures of his own, and an uninitiated reader will never realize that the quantities given under the heading of "Hayford compensation" have not been deduced by Hayford's method.

Mr. Oldham's reference to the Aravalli Mountains is equally inaccurate. This range traverses Rajputana in a north-easterly direction, and terminates near Delhi as a small ridge which is an insignificant topographical feature. Mr. Oldham recalls a geological suggestion made many years ago that this range may once have extended across the Gangetic trough into the Himalaya. He now quotes the deflections of the plumb-line at three stations as evidence in support of this suggestion (p. 97). Two of these deflections however furnish no evidence on the point, whilst the evidence of the third (Sarkara) is adverse. Any reader can check my criticism by examining the map attached to the memoir. If the Aravalli axis is produced it will pass north-west of Sarkara; this will not diminish the northerly deflection at Sarkara. Yet Mr. Oldham sums up as follows: "The geological structure has suggested the possibility of an original extension of the Aravalli range into what is now the Himalayan region; the geodetic observations have supported this suggestion and converted what was only a bare possibility into something more than a probability."

So mistaken indeed are Mr. Oldham's ideas of geodetic principles and accuracy, that when he found his calculation of the depth of the alluvium at Agra was not in accord with the depth obtained by boring, he attributed the disagreement not to his own hypothesis but to the geodetic data (p. 80). He avoided this disagreement not by reconsidering his own assumptions, but by altering the observed results. On p. 112 he says he found it "necessary to apply a correction of $-0{\cdot}02$ dyne" to the pendulum results as the latter did not give the depth of the alluvium correctly: and he even suggested that this Agra correction might be applied to Basevi's observations at Moré. The scientific precautions taken in the observation of pendulums become useless if the results, obtained by labour and care, are to be treated as they are in this memoir.

LETTER FROM MR. STEFÁNSSON

[We have much pleasure in publishing the following letter from Mr. Stefánsson, written on 20 July 1918 from St. Stephen's Hospital, Fort Yukon, Alaska. In a covering letter Mr. Stefánsson gives the excellent news that although he does not expect to be quite well for several months, he has sufficiently recovered from his long illness to be able to undertake a lecture tour on behalf of the funds of the Red Cross, beginning at New York on October 6 under the auspices of the American Geographical Society and the American Museum of Natural History.—Ed. *G. J.*]

I HAVE recently seen in your *Journal* for February and May of the current year two short references to the work of the Canadian Arctic Expedition. They are as correct as the news sources on which you had to draw admitted.

The impression that I had arrived at Fort Yukon last Christmas was based on the newspaper assumption that I was myself present at the telegraph station from which my messages were sent to the Government and others. I had, however, sent them from the vicinity of Herschel Island by a south-bound trader whose vessel, the *El Sueno*, had been frozen in at Herschel. This was Captain Alexander Allan, who during 1915–16 was connected with the southern wing of our expedition.

It was correctly announced by Dr. Anderson (as you have it in your February note) that my intention was to have the *Polar Bear* attempt to proceed in 1916 from her base near Amstrong Point, Victoria Island, to winter on South Melville Island. She was then to continue south in 1917 by the well-known eastern route. I gave the appropriate orders to the *Polar Bear*, but, during my absence in our new islands north of Melville Island in the summer of 1916, they were not carried out, and the vessel in fact proceeded about 100 miles south, and wintered near Collinson's old quarters in Walker Bay. The reason for her doing so cannot be entered into here. In the summer of 1917 the *Polar Bear* sailed for the mainland before our spring exploring party had time to get south to her. The members of our sledge exploring parties of the springs 1916 and 1917 saw neither the *Polar Bear* nor any other vessel from mid-winter of 1915–16 till September 1917. Seventeen of us spent the winter 1916–17 in Melville Island on Liddon Gulf and at Cape Grassy. Our houses were musk-ox hide, our fuel was locally discovered coal, our food