

belt southward towards the Atlantic ocean carried the equatorial currents nearer to the polar ones, thus inviting frequent atmospheric disturbances and resultant storm action. As the hot, vapour-laden winds, fertile in elements and force, met the southern cold ones, a prodigious amount of heat was set free by condensation. Into the vacuum thus created the opposing currents rushed with ever-increasing rivalry, enlarging the area of mechanical action, condensation, and vacuum, and augmenting the violence of the storm-waters, which, sweeping along the mountain slopes, must have rapidly disintegrated and eroded them, and have acted as a potent agent to transport to their base much of the material from which the Pampean beds were sifted. The rainfall over the inter-Andean region must have produced many large lakes similar to Lake Titicaca, and a great river system, which, tributary to the Colorado, swelled it into a stream of the first rank, pouring into it the sand and silt which have completely filled the enormous estuary, the outline of which is still traceable.

One may believe that an increased rainfall gave a luxuriant vegetation, where herds of gigantic mammalia found feeding-ground; from which, from time to time, they were swept, by storm or swollen river, into the Pampean sea, where also they may have lost their lives in other ways, their remains being distributed over it by the currents.

To a minor degree the ancient sea and lake must have affected the inter-Andean climate, from Cuzco to the south, throughout the lacustrine basin of Titicaca, giving it greater rainfall and fertility than it now has. Geological examinations show that Titicaca was once one of the large lakes of the world, and that it has slowly been drying up. Does its gradual diminution date from the disappearance of the Pampean sea and Mojos lake?

Savage man may have lived in South America on the mountain slopes round the ancient sea. If so, he possibly hunted the mastodon, the megatherium, and numerous other of the gigantic fauna which probably were co-existent with him. His only highway, between the eastern and western halves of the continent, must have crossed the elevated region at the head of the Pampean sea, lying between 17° and 19° S. lat., which is still the only route in use for communication by land between Bolivia and Matto-grosse.

## A GREAT GLOBE.\*

By Professor ÉLISÉE RECLUS.

RECENTLY being in conversation here in London with a traveller and discoverer, I mentioned the great geographical importance of accurate representations of our planet in the shape of globes; suddenly he interrupted me, and said with a smile, "What is the use of your Lilliputian globes, ten, a hundred, or a thousand yards thick, when you have the very globe itself, our good and beneficent Earth, to walk over, to look at, to study, and to love?" Of course I laughed, and thought with him that all representations and symbols of life are very little in comparison with life itself: our works are small when contrasted with nature. But the great man who thus spoke in joke knew as well as I do, the value of scrupulous effects in geographical work. He has himself drawn very useful maps, which enable us to follow him in his great travels. We cannot all perambulate the surface of our planet, but we may still be very useful in a secondary way. The great question is to know in what direction

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we are to exert ourselves in order to produce the greatest amount of perfect scientific labour. The chosen few will make discoveries; the others, less fortunate, but happy still, will follow in the track opened to them.

One of our eminent geographers, who is present at this meeting, Dr. Hugh Robert Mill, gave us, a few years ago, a lecture on the "Geographical Work of the Future," and put great stress on this, that "accurate cartographic representation is the very essence of geography." Certainly he was right. Accuracy of design is of paramount importance, and this is the reason why geodesists measure the surface of the Earth with such wonderful care and precision: a difference of a few millimetres on two measurements of a line of base is justly a great matter of discussion, and obliges the scientific bodies to begin the work again. Thus a perfect exactitude is obtained in geodetic calculations, and the real distances and proportions of all geographical features are triumphantly made out; but the results, although fulfilling all expectations and perfect in registers and tables, are in a certain measure practically lost on the deceitful maps and charts: their truthful representation is quite out of the question, at least for all parts of the figure which are not delineated on the centre of the map. A plane surface never will nor can be the real representation of a spherical surface. Splendid devices may be imagined by the mathematicians to lessen the importance of errors according to this or that dimension of the map, but although I do not deny the immense convenience of maps, without which there would be no geography at all, still we may point out the errors which will subsist, and sometimes we feel tempted to ask, "What's the use of having secured perfect accuracy in measurement, within one millimetre, when on paper the errors must amount to yards, furlongs, and miles?"

There is only one way to represent truly the surface of the Earth. Curves are to be translated in curves; a sphere or fragment of a sphere must be reproduced by another sphere or fragment of sphere. Therefore are we really astonished that public attention and the special care of geographers are so little attracted towards this logical mode of geographical work.

The progress of cartography proper has been really immense. When we compare the maps and charts which are now constructed by the various industrial, maritime, and military staffs with the very interesting maps of the last century, which had been also constructed with great care by the best geographers and at very great expense, we are struck by the marvellous increase of those documents, not only in quantity, but also in quality. I may say that certain maps, where the scale is very large, and which, in fact, may be considered part of an immense globe, are at the same time so gloriously embellished by colours and graduated tints that they are really wonderful to look at, both as true representations of nature and as marvellous works of art. The impression which genuine geographers feel is very near or even entirely similar to that of an artist before a glorious picture or statue. To see nature itself, and to behold at the same time a picture of it in perfect accordance with the reality, is positively a rapture. As examples, there are the official maps of Switzerland or the Bay of Naples.

But, returning to sphærography, we must avow that there are very few globes or segments of globes which have been made with sufficient care to be held in comparison with the best charts. Generally they are much less scrupulously drawn, being constructed more for show than for science; they are less worthy of attention. Of course, some of the elaborate globes which have been issued by various publishers are altogether very creditable objects, but few are to be studied with the same confidence as maps in almost all civilized countries. Some of the globes which have been constructed are huge in dimensions. There is one cut in a rock, I believe, on the seashore near Bournemouth, but I don't know if it has any real

value. There was one at the last Paris Exhibition which was some 120 feet in circumference, being one-millionth of the mother Earth to scale, and I must say this gigantic globe has left on minds of the three hundred thousand people who saw it a very deep impression, by the mere comparison of dry land and sea, and the large proportions of countries which are ordinarily shown in Lilliputian forms in most atlases. I remember, also, the real feeling of rapture which pervaded me when, in my youth, I walked inside of Wylde's globe, near this very place, admiring the magnificent sight. But that noble structure, as well as the Paris Exhibition globe, made no pretence to accuracy in geography proper; they had been designed only to be looked at from afar, without any special study of minor details.

The Paris globe was to be seen from the outside, on a winding staircase; the London Wylde's globe, forgotten now by our contemporaries, was seen from the inside, and was to be contemplated at one circular glance. According to Alfred Russel Wallace, whose opinion has such great weight, the last method would be really the best.

I repeat it again, this department of geography, sphærography, although the most important to develop, has not kept pace with the other, cartography, and I presume it will be a real revolution when it has taken in science and practice the paramount place it deserves. At present small globes are very much in use for schools, but we know how that part of the educational furniture is shamefully neglected; the very fact that it is found in elementary classes is one cause of the disdain in which globes are generally held. There is, perhaps, another reason. Globes of large proportions are very cumbrous objects, and in our crowded cities, where space is so expensive, it is very difficult to find place for these scientific guests. And, above all, the best of reasons is that education has not been yet directed in that way, and people, even scientific people, are not yet sufficiently convinced of the absolute necessity there is to study geography on images of our planet reduced to a commodious scale and with the real proportions. There is no geographer, however learned and accustomed to the reading of maps, who is not constantly at a loss to understand immediately, at the sight of charts drawn on all kinds of scales, what exact proportions the country represented bears to his own land or district. He will not see the real state of things; he will try to remember the figures he has learnt by heart, or make tedious calculations, which are a great loss of time.

So it is that for us all, learned or unlearned, the direct study of geography on spherical surfaces is absolutely necessary. If the scale of the globe is very small in comparison to the real dimensions; if it is, for example, in the proportion of only one to 10 or 20 million, then the surface is to be kept even—polished, we may say—because the roughness of the highlands and mountains cannot be represented with sufficient relief. On such a ball, 6 or 12 feet in circumference, the highest mountain of Himalaya would not represent  $\frac{1}{25}$ th of an inch in height, and the ordinary hills would hardly alter the regular surface of the globe. But, with larger spheres or fragments of spheres, another element of truth and beauty is added to the construction; the actual relief appears on the curvature of the model.

And here allow me to say, once for all, that the system of exaggerating the proportional height of hills and mountains on the surface of globes is utterly bad, contrary to real science, and ought to be discouraged by all geographers respectful of nature and its laws. In that way the utmost ugliness is attained; people who do that kind of work seem to think themselves above all sense of reality. Thus we hear that the ladies of the Philippine islands, wishing to make a valuable present, imagined to have a representation of their archipelago made by a jeweller

with rubies for the cities, sapphires for lakes, and other costly stones for volcanoes. Of course, many thousand pounds were expended for that miserable rubbish.

All the pseudo-relief maps which show us slopes with two, three, fifty, one hundred times their real proportions in height, inconsistent with the facts, and violating the forces of gravitation, are the logical consequence of a childish desire to represent grand sights as if they were always stupendous, wonderful, next to miraculous. It is in the same spirit that, during the first part of this century, before the invention of photography, painters were prone to exaggerate in their pictures twice, or even three times, the real proportions of mountains in altitude; conscious in a certain measure of the deficiency of their art, they relied on falsehood to make it more eloquent. Happily, new discoveries have enrolled the sure, the victorious light of the sun on the side of truth, and now we have by thousands and by millions splendid pictures of mountains, which give to our eyes the true sense of proportion, and certainly do not diminish our conception of beauty.

The revolution which photography has accomplished in pictorial art is to be achieved also in relief construction. We are to be most strict in one thing—keep always to the truth. It is the best plan in scientific work as in life. Truth in scales: therefore it is that we must use globes instead of maps as frequently as possible. Truth in heights of relief: therefore do we leave entirely out of question the idea of showing any apparent roughness on globes or fragments of globes under the scale of one-millionth. On such balls colours and shades only will be convenient to represent the various altitudes on the Earth and depths in the sea.

But as soon as the globe or fragment of globe is large enough to show at least one-millionth part of the Earth in real proportions, then we may try to represent as well the heights and depths as the planimetric dimensions. Of course, the chiselling and moulding of the surface will be more and more elaborate in proportion to the increase of the scale. On a globe of one-millionth, the great masses of highlands and mountains, 3000 feet in height, will hardly appear above the plains, and only by the contrast of light and shade; but summits of 10,000 or 12,000 feet will be seen perfectly well—the more so, that to show forests, pastures, snow or ice, various colours and tints will heighten the effect as they do in reality. If the size in diameter be doubled, the impression of the sight is increased, and the relief is represented with much greater accuracy. If you construct a very large globe on the scale of 1 to 100,000, then all the details of elevation and depth will appear most distinctly, even hills and hillocks 150 feet in height. You see the very Earth as if you were sailing above it in a balloon. The representation of such heights, whose appearance our eyes are accustomed to, gives us an unexpected advantage by furnishing us with a standard of comparison. To give us an idea of the real height of a building, photography and painters put men or women standing all around or leaning against the pillars. Thus spectators of a relief will easily estimate, by comparison with known heights, the real dimensions of the hills and mountains which diversify the surface.

There has been in Switzerland lately a very interesting public controversy. A skilful cartographer and relief maker (M. Charles Perron) had proposed to the Federal Council to construct, for the Paris Exhibition, a relief of Switzerland on the scale of 1 to 100,000, which, he said, would do honour to the country; and, indeed, the samples of the work which he exhibited at Bern and Geneva excited general admiration. Evidently the undertaking deserved to be encouraged, and it would have been taken under the official patronage of the Swiss Republic if a few influential geodesists had not interfered, asserting that a true and perfectly detailed representation of nature wanted a larger scale than the 100,000th. As in examples of their contention, they referred to the parting of slopes on nearly horizontal ground;

the geographical changes brought in the configuration of a valley by the advance of a morainic ridge; the displacement of the courses of rivers caused by landslips and erosions—all facts of small magnitude in their origin, but of great geographical importance, and which are to be fully represented on large relief to be clearly understood. Pamphlets and articles were published on both sides, and the question was fully elucidated by most competent scholars.

Now we may resume the discussion. According to the effect which must be attained, and the elaborate study which is aimed at, scales must be different in globes, as also they are in all other modes of representation, maps, charts, and plans.

If our intention is to show the majestic appearance of the Earth, with its continents and seas, with its mountains, rivers, and plains, if it is to give a perfect idea of the interaction and interdependence of all organs in the grand planetary body; then, by all means, let us construct a large globe, where we may be impressed by the mass itself, by the harmonious forms of the countries we know, and specially love and study. But if our aim is to show the details as, thoroughly as possible, and the means be not sufficient to construct the globe at a convenient scale, the only way is to model fragments or parts of sphere in proportion of 1 to 50,000, 25,000, 20,000, 10,000, 5000, as may be desirable. With the increase of these treasures, geographical societies will acquire documents enough to represent in reality whole parts of the Earth in miniature, attaining the utmost perfection, and satisfactory both to the learned and the artists.

This is, in fact, the thing which will be done in Switzerland. Two objects are to be attained, and therefore work will be directed in both ways. I hear M. Perron's great work will be pushed on with great enthusiasm, and we may hope to see, two years hence, in the Paris Exhibition, his complete relief of Switzerland on the scale of 100,000—the most complete, and certainly the best of the kind, which geography will possess; and, on the other side, all those who have carefully inspected the Polytechnium in Zürich know what splendid achievements local geodesists have made in the shape of mountain-reliefs on very large scales, showing and explaining at the same time the features of the country. Nowhere in the civilized world do we find so much and so great work accomplished in the way we recommend.

Among the conquests of a proximate future, I think a better division of labour will be introduced in geographical bodies. Already a very great improvement has been made in the scales of maps, especially for large geographical works. Nearly all these are now constructed according to a scale with very convenient decimal numbers, 100,000, 50,000, 40,000, 20,000, which allow us easy arithmetical comparison, all numbers being a multiple or a decimal fraction of another. The United States squeezed, so to say, between two tendencies, to measure still in the ancient way, by inches or parts of an inch to the mile, or to deal with great decimal masses, have chosen for their maps the various scales of 250,000, 125,000, and 62,500, which last measure is so very near to the proportion "one inch to the mile," that it may be considered as practically the same. In reliefs, even more than in maps, the habit has become general to take regular scales with full thousands and tens of thousands; thus comparisons are more easily made between the various productions. This tendency of relief-makers will, I hope, grow more and more common, and gradually, by mutual, though informal, agreement, their works will be made according to a few commodious patterns, and constitute as many different parts of great globes constructed on the same scale. If all these disjointed and scattered parts, well reproduced and regularly exchanged between the authors and the geographical societies, were collected and put together, the construction of entire globes on very large scales would be found very much

advanced. People would be astonished to see what large fragments of continents in relief we already possess, if they saw in a great hall, put in their proper place, all the plans of the Alps, Pyrenees, and Auvergne, and other mountainous lands. These relief constructions on large scales are the necessary complement to the lesser globes, for whose construction we plead urgently.

This spontaneous organization of labour which pervades the scientific workers in the common field will prevail more and more. We see already the various geographical societies uniting every year more intimately to distribute the business among themselves. Small societies have their very important part for local efficiency, and we may expect from them searching studies on the special questions relative to their own or surrounding countries. Larger bodies residing in important seaports or commercial centres have a greater field of action, and their natural circle of study embraces especially the parts of the world which belong to the general market of their cities; lastly, the societies, whose area of action and reaction is the immense world at large, are invested with a mission of high and noble import—to centralize every document belonging to the Earth at large, and to any part of it specially; to collect in their libraries all the books, all the pamphlets and documents, that have been written or published anywhere in the world; to have the entire set of maps, charts, and plans which have been constructed and drawn by geographers and engineers in the entire world; and especially to offer to their guests, who are, so to say, the delegates of all mankind, a model of the Earth, under the shape of a globe, vast in dimensions, where every man will find himself at home, and even will learn to know his own country better than before, where he may also indicate all possible corrections and improvements;—such a model, in fact, which will afford a standard of scientific perfection which human intellect and skill are able to attain. This is, I think, what the legitimate ambition of a geographical society ought to realize, and will certainly realize, in the proximate future.

Among all the riches which I foresee in our palaces and museums on geography, there is one, as is implied in the subject of my lecture, to which I look forward with an intense desire. Now, at a time when every morning and evening newspaper brings us news from all parts of the world; when every one of us, even the least fortunate, is fed and clothed with productions of all continents and seas; when we all have friends across both oceans in the antipodal countries;—the moment has come for us to have grand representations of our common home, and not to satisfy ourselves with petty spheres, round copper balls, similar to that which Krates of Melos exposed to the curiosity of men in the temple of Pergamos, twenty-one centuries ago. Now Globes must be temples themselves, as well by the magnificence or proportions as by the beauty of workmanship and the scrupulous care of scientific drawing. In sight of such constructions, people must feel grave and respectful, not only because those monuments consecrated to science will partake of its majesty, but also because they will belong to all men, without any privilege for race or nationality, and will help to strengthen within us the feeling that we are one and the same family.

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Before the reading of the paper, the PRESIDENT said: We have with us this evening one of the most celebrated and eminent geographers now living, M. *Élisée Reclus*. He has come amongst us to give us his views respecting the use of globes. I now request M. *Reclus* to read his paper.

After the reading of the paper, the PRESIDENT said: I have no doubt several geographers will wish to discuss this extremely important paper which M. *Reclus* has just read to us. I will first call upon Prof. *Geddes*.

Prof. *GEDDES*: In these days of peace and war, I do not think that we need