THE PERMANENCE OF OCEAN BASINS.

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AN interesting discussion has recently taken place in the pages of *Natural Science* upon the question of the relative permanence of oceanic and continental areas. Dr. A. Russel Wallace comments on the remarkable convergence of independent lines of research which led Professor Dana, Mr. Darwin, Sir Archibald Geikie, Dr. John Murray, the Rev. O Fisher, and himself to the same conclusion, that continents and oceans have not changed places in geological times. He adduces

three new arguments in favour of these views:-(1) The enormous disproportion between the mean height of the land and the mean depth of the ocean, which would render it very difficult for new land to reach the suface till long after the total submergence of the sinking continent; (2) the wonderful uniformity of level over by far the greater part of the ocean floor, which indicates that it is not subject to the same disturbing agencies which throughout all geological time have been creai ng irregularities in the land surface-irregularities which would be far greater than they are were they uot continually counteracted by the lowering and equalising effects of subaerial denudation; (3) the remarkable parallelism and completeness of the series of geological formations in all the best-known continents and larger continental island!!, indicating that none of them has risen from the ocean floor during any era of known geological history-a conclusion enforced by the absence from any of them of that general deposit of oceanic ooze at some definite horizon, which would be at once the result and proof of any such tremendous episode in their past history.

!b-. Jukes-Browne combats the theory of the permanence of original oceanic and continental areas by pointing out that, as a matter of fact, deposits which must have been formed in very deep water have been detected in elevated land, He denies the force of the second argument quoted above on account of our comparative i_{gn}orance of the details of sub-oceanic geography, and be◆use long-continued sedimentation must have tended to reduce the irregularities of the ocean floor, which would in any case be less than those of the continents, and, finally, because Mr. Fisher's theory of the sub-oceanic outpouring of lava might account for the uniformity of the ocean-bed. Mr. Jukes-Browne also shows how it is possible that the volume of the ocean was formerly very much less than it is now, and that in consequence of the release of water from chemical union with hot rock-material by volcanic explosions the volume has been steadily increasing. Hence, in palreozoic times, he argues that the land area may actually have been in excess of the water area, and the continental plateaux might have been much less elevated above the ocean floor than they are now-that, in fact, the elevations and depressions might not have been of the character of continent and ocean-basin at all.

Mr. Jukes-Browne's remark as to long-continued sedimentation obliterating the irregularities of the ocean floor requires proof. *Dr.* Murray bas shown that the shallower the sea is the more rapidly does sedimentation far from land proceed, sedimentation tending to exaggerate and not to obliterate, initial differences of level.

Dr. W. T. Blanford, whose name bad been mentioned in the articles us an opponent of the theory of the permanence of oceans and continentA, cir.plained that he objected to strong statements on either side, and urged great caution in forming opinions from such incomplete data as we

possess. He objected, os did Mr. Jukes-Browne, to assuming that no part of the sea-bed at a depth exceeding 1000 fathoms has ever been dry land; but Dr. Wallace explained that ho took the 1000-fathom line as only an approximate boundary, and even in the fil'llt edition of 'Island Life' admitted certain exceptions. Hence his advance to 1500 or even 2000 fathoms in some cases did not affect the consistency of his views.

Professor James Geikie in his address to Section E of the British Association last year *(Proceeding,* for 1892, p. 638), touched upon the interchange of elevation on the continental margin, and Dr. Blanford quotes his statement as one fairly representative of modern views on the subject. He says, "The continental plateau and the oceanic hollows have never changed places, although from time to time portions of the latter have been ridged up and added to the margins of the former, while ever and anon marginal portions of the plat.eau have sunk down to very considerable depths." In a paper on the "Evolution of Climate," published in the *&otti,h Geographical Magazine,* vol. 6 (1890), p. 57, Professor Geikie gives a series of maps showing tho approximate distribution of land and water at different geological periods, a re-statement with new data of Dana's earlier work. He understands the evolution of continents to be a transition from insular groups ofland to a solid coutinentalform, the island groups appearing upon the gradually emerging continental plateau. The diversity in opinion of students of this department of physical geography seems to be due rather to individual differences of confidence in drawing conclusions, than to any serious conflict of belief ns to lho bearing of ascertained facts.

The actual dividing lino to be assumed between the oceanic and continental areas is obviously to a largo extent arbitrary. Tho great ocean basins nro comparatively flat-floored, the continental areas bounded by the 100-fo.thom lino are, in a general way, roof-shaped, partly flat, partly composed of steep irregular slopes. Between these two great and definite regions there is everywhere a wall or zone of transition equally definite, forming a relatively abrupt descent. Along the slope of the entire development of this zone the difference of vertical height for a given horizontal displacement at right angles to the contour lines is greater than in any other part of the Earth, a few mountain ranges excepted. The line separating the two areas must lie somewhere on this slope. The 2000-fo.thom line lies near the bottom of the slope close to t.he ocean floor, the 1000-fathom line lies nearer the top than the middle of the transition zone.

Calculating from Dr. Murray's data, I showed in 1890 *(Proceeding,.* Roy. Soc. Edin., vol. 17 (1890), p. 185), that the contour line of 1700 fathoma divided the surface of the Earth almost exactly into two equal parts, one a nearly continuous area of elevation, the other an equally continuous area of depression. This line I termed mean-sphere level, because it had the remarkable property of repre-

senting tbe intersection of a geoidal shell, the depression of the crust below which was equal in volume to the protuberance of tho continents above it. The exact position of the line of mean-sphere level it is, of CO'll"88, impoesible to determine until the volumes of oceans and continents below and above sea-level have been accurately ascertained, and until sea-level is itself corrected for gravitational distortion, but the position cannot be very far removed from that assigned to it. The accompanying sketch-map on Lambert's equal-area project.ion serves to show graphically the two great nrea.I of elevation and depression separated by the line of mean-sphere level. The area of depression may be termed the abysmal area, a name which Dr. Murray originally applied to the region lying at a depth greater than 1000 fathoms; the elevated half includes the dry land or continental area proper, and the transitional area or flanks of the continental plateau, at present covered with water. If any compressi,o stress were limited to one-half of tho

area of the Earth's surface while the crust was plastic and undistorted, the surface being everywhere at mean-sphere level, a mass would be elevated over the free half to such a height as would, by its weight, balance the force of the pressure causing tho depression, and if the density of the cruet were uniform tho depressed and elevated volumes would be the same. It seems probable that the series of changes which have evolved continents and oceanic hollows may be related to the line of mean-sphere level, tho position of which corresponds with that which Dr. Wallace has been led to adopt as his boundary between ooeanio and continental areas. By the adoption of this physical constant some of the objections to the theory of permanence are overcome, especially that which charges thoso to whom the evidence seems more complete than it does to others with a change of ground when they slightly modify an approximate and largely arbitrary limit.

The main fact, conceded by all who have studied the subject, is, that there is such a thing as the evolution of continents, the heights and hollows of the Earth's crust having become greater with the lapse of time. And all, also, concede that the present ocean basins represent regions where subsidence has predominated over elevation, while the continental area is that in which elevation has been more active than depreBBion. Thus the actual level of the sea is an accident depending on the volume of its water and the inequalities of the crust, equal variations in which, on the hypothesis of constant volume in the ocean, may have led to very different emergence or submergence of the border areas according to the angle of the slope. At present the coast-line lies nearly mid-way on the flattest expanse of the continental margin, so that a given increase or decrease in the volume of the ocean would cover or lay bare the largest poBBible area of land.