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"The Council, concurring in the finding of the Committee, and warmly approving of the recommendations contained in its Report, unanimously resolved to support any movement having for its object the careful exploration of the Antarctic Regions, as being certain to result in large and important accessions to our knowledge of Geography, Oceanography, Meteorology, and other branches of Physical Science. The Council are, moreover, of opinion that any expedition despatched to the Antarctic Regions in the prosecution of these objects, should be undertaken at the expense of Her Majesty's Government. It may, however, be worthy of consideration, whether the co-operation of the Governments of Australia, New Zealand, and Tasmania might not be invited in an expedition such as this, which is of an Imperial character.

"The Council would suggest that a Conference be held in London at an early date, composed of delegates from the leading Scientific Societies in Great Britain and Ireland, to consider the scheme, and draw up a joint memorial to Her Majesty's Government in support of the expedition.

"The Council directed that copies of this Resolution be forwarded to the Special Committees of the British Association, the Royal Society of Edinburgh, the Royal Society of Victoria, and the Australasian Geographical Society—who have already drawn public attention to the advisability of further Antarctic research—and also to the Royal Society of London, the Royal Irish Academy, the Royal Geographical Society, and other learned bodies."

DRAINAGE AREAS OF THE CONTINENTS AND THEIR RELATION TO OCEANIC DEPOSITS.

BY JOHN MURRAY.

(Read before the Royal Society, Edinburgh.)

WHEN engaged in the study of the Physical Geography of the Globe, it is frequently essential to represent the various areas and data which are being dealt with on maps, for thus we often arrive at a more just conception of the relation of these areas or data to one another. The choice of the kind and size of the map to be used is a matter of first importance, and is usually determined by the nature of the facts to be represented.

Some time since, when working at the description and distribution of oceanic deposits, my attention was specially called to the choice of a map for the purpose of representing the areas occupied by the various deposits.

The sphere being non-developable, the exact representation of any portion of its surface upon a plane is impossible. We must choose between a map which preserves the angles and form of any area, but in which the areas are not proportional to the surface of the map representing them, as, for instance, in Mercator's projection, or one, in which all

the areas on the sphere are reduced in the same proportion on the map, but the angles and outlines are more or less distorted, in which case we have an equivalent projection. The latter kind of map was evidently that best suited for my purpose. Among the infinity of systems of projections which do not alter the areas of the surfaces comprised under different contours, Professor Chrystal advised me to adopt that known as the *Central Equivalent Projection*, as best adapted for the purposes of the investigation.

This projection was discovered by Lambert in 1772, and is described at length by Collignon and Germain. The system is founded upon the principle of elementary geometry, that the area of a zone of a sphere equals the product of the circumference of a great circle by the height of the zone. It follows from this that the area of the zone is equal to the area of the circle, whose radius is equal to the rectilinear distance from the pole of the zone to the circumference, which serves as a base. It is thus obvious that any portion of a spherical surface may in this manner be represented on a map without alteration of area, and that any point on the sphere may be assumed as centre of the map. The distortion of angles and outline, which is nothing at the centre of such a map, becomes greater as we proceed towards the circumference. In this month's *Magazine* there is a map of the Antarctic Regions on this projection.

Mr. Bartholomew has constructed for me four maps on this projection, representing hemispheres of the globe. The radius of the circle is nine inches, so that the areas represented on the maps are equal to those on a sphere, the chord of one of whose quadrants is equal to nine inches. As I wished to deal chiefly with the Oceans, the centre of the Pacific Ocean was taken as the central point of one of the hemispheres, and the antipodal point the centre of the other. In the second set a central point in the Atlantic is taken as centre of the one map, and the antipodal point the centre of the other.

In the maps now before the Society, Mr. Bartholomew has shown the land draining into the different oceans, inland seas, and continental basins. The data have been taken from the best and latest authorities, the coast-lines being based on the English Admiralty Charts, and the interiors from the most authoritative maps, including those showing the discoveries of recent explorers as late as February 1886. The watershed lines have in every case been sketched out on large-scaled maps, where the river systems of the continents are shown in detail. From these the water-parting lines have been reduced to the present scale.

If now the areas on the map be proportional to the areas on the terrestrial globe, we should be able to estimate, by means of the planimeter, the various areas in square miles with a considerable degree of accuracy. This has been done, and I find that the result is most satisfactory for all but very small areas.

The method is as follows:—

The area of the four maps by calculation should be $2 (2\pi r^2) =$

508·93758 square inches. By means of the planimeter, the mean of three observations for each map gave area = 508·71, a very close approximation to the truth.

I had calculated the total number of square miles on the surface of the globe by taking the mean of the most recent values of the semi-axes of the globe, and thus ascertained the number of square miles represented by a square inch on the map; when Professor Chrystal undertook to calculate the number of square miles there should be, regarding the earth as a spheroid of revolution. I append the formula used by Professor Chrystal, and the calculations and data made use of. The nearest approximation that can be assigned to the whole surface of the globe, as given by this calculation, is as follows:—

148,572,700 square geographical miles,
or 196,940,700 square English miles.

These numbers exceed by about 200,000 square miles those usually given in the books.¹

Taking these numbers as the basis of the calculations, each square inch on the maps represents 387,137 square English miles, or 292,058 square geographical miles.

Proceeding in this manner, the areas of several well-known countries were ascertained, and the results were found to agree in a remarkable way with those obtained by other methods.

I subjoin the results obtained of the areas of the various continents and their hydrographic basins.

¹ Calculation of the surface of the earth regarded as a spheroid of revolution whose semi-axes are—

$$a = 20926202 \text{ feet} = 3963\cdot295833 \text{ English miles.}$$

$$b = 20854895 \text{ feet} = 3949\cdot790719 \text{ English miles.}$$

The accurate formula is

$$S = 2\pi a^2 + \pi \frac{b^2}{e} \log_e \frac{1+e}{1-e}, \text{ where } e = \sqrt{1 - \frac{b^2}{a^2}}.$$

This may be replaced by the following—

$$S = 2\pi a^2 + 2\pi b^2 + 2\pi b^2 \left\{ \frac{1}{3}e^2 + \frac{1}{5}e^4 + \frac{1}{7}e^6 + \frac{1}{9}e^8 + \frac{1}{11}e^{10} + \dots \right\}$$

Or say by—

$$S = 2\pi a^2 + 2\pi b^2 + 2\pi b^2 \left\{ \frac{1}{3}f + \frac{1}{5}f^3 + \frac{1}{7}f^5 + \frac{1}{9}f^7 + \frac{1}{11}f^9 + \dots \right\}$$

where $f = e^2 = 1 - \frac{b^2}{a^2} = \frac{a^2 - b^2}{a^2}$.

We have $a^2 = 15707713\cdot86$ $b^2 = 15600846\cdot72$

Whence	$f = \cdot006803481203$	$\frac{1}{3}f = \cdot002267827067$	
	$f^2 = \cdot000046287356$	$\frac{1}{5}f^2 = 9257471$	
	$f^3 = 314915$	$\frac{1}{7}f^3 = 44988$	$2\pi a^2 = 98694476\cdot93$
	$f^4 = 2142$	$\frac{1}{9}f^4 = 238$	$2\pi b^2 = 98023010\cdot89$
	$f^5 = 14$	$\frac{1}{11}f^5 = 1$	$2\pi b^2 g = 223211\cdot11$
		$g = \cdot002277129765$	<u>196940698·93</u>

196940700 is as near as the observations will allow us to calculate.

DRAINAGE AREAS OF THE LAND.

AFRICA, INCLUDING MADAGASCAR.

	Square Geographical Miles.	Square English Miles.
Three inland drainage areas :—		
Sahara Desert,	2,602,250	3,449,400
Kalahari Desert,		
Eastern Abyssinia, }	84,700	112,250
Indian Ocean drainage area,	1,588,800	2,106,050
{ Atlantic Ocean do.,	3,095,800	4,103,650
{ Mediterranean Sea do.,	1,141,950	1,513,700
Madagascar (Indian Ocean),	178,150	236,150
	<u>8,691,650</u>	<u>11,521,200</u>

EURAL-ASIA, INCLUDING BRITISH ISLANDS, ICELAND, JAPAN, SAGHALIEN,
FORMOSA, ETC.

{ Central inland drainage area,	3,609,850	4,785,000
{ Three inland drainage areas in Arabia and Asia Minor,	589,950	782,000
Pacific Ocean drainage area,	3,011,100	3,991,400
Indian Ocean do. do.,	2,354,000	3,120,300
Arctic Ocean do. do.,	3,668,250	4,862,450
{ Baltic Sea do. do.,	461,450	611,700
{ Mediterranean Sea do.,	1,071,850	1,420,800
{ Atlantic Ocean do.,	540,300	716,200
	<u>15,306,750</u>	<u>20,289,850</u>

NORTH AMERICA, INCLUDING NEWFOUNDLAND, WEST INDIES, AND GREENLAND.

Five inland drainage areas, viz. :—		
Great Salt Lake basin and four minor Mexican basins,	210,300	278,750
Pacific Ocean drainage area,	1,410,650	1,869,900
Atlantic Ocean do. do.,	2,508,800	3,325,500
Arctic Ocean do. do., including Hudson's Bay area,	2,830,050	3,751,350
	<u>6,959,800</u>	<u>9,225,500</u>

SOUTH AMERICA.

Two inland drainage areas of Peru, Bo- livia, Argentine Republic, and Patagonia,	394,300	522,650
Atlantic Ocean drainage area,	4,611,600	6,112,900
Pacific Ocean do. do.,	330,000	437,450
	<u>5,335,900</u>	<u>7,073,000</u>

AUSTRALIA, TASMANIA, NEW ZEALAND, EAST INDIES, NEW GUINEA,
PHILIPPINES, ETC.

Inland drainage area (Australia),	1,174,050	1,556,300
Indian Ocean do. (Australia, Tas- mania, New Guinea, etc.),	928,750	1,231,100
Pacific Ocean drainage area (Australia and Tasmania),	239,500	317,450
Pacific Ocean drainage area (New Zea- land),	73,000	96,800
Pacific Ocean drainage area (East Indies, New Guinea, Philippines, Polynesian Islands),	619,150	820,700
	<u>3,034,450</u>	<u>4,022,350</u>

SUMMARY OF LAND AREAS.

	Square Geographical Miles.	Square English Miles.
Africa, etc.,	8,691,650	11,521,200
Eural-Asia, etc.,	15,306,750	20,289,850
North America, etc.,	6,959,750	9,225,450
South America,	5,335,900	7,073,000
Australia, etc.,	3,034,500	4,022,350
	<hr/>	<hr/>
Antarctic Continent,	39,328,550	52,131,850
	2,689,850	3,565,550
	<hr/>	<hr/>
Total Land on the Surface of the Globe,	<u>42,018,400</u>	<u>55,697,400</u>

INLAND DRAINAGE AREAS.

INLAND DRAINAGE AREAS.				
Africa, three areas :—				
Sahara Desert,	.	.	2,602,250	3,449,400
Kalahari Desert,	}	.	84,700	112,250
Eastern Abyssinia,		.		
Eural-Asia, four areas :—				
Central area,	.	.	3,609,850	4,785,000
Three areas in Arabia and Asia Minor,	.	.	589,950	782,000
North America, five areas :—				
Great Salt Lake and four minor	.	.	210,300	278,750
Mexican basins,	.	.		
South America, two areas :—				
Peru, Bolivia, Argentine Republic,	.	.	394,300	522,650
and Patagonia,	.	.		
Australia, Central area,	.	.	1,174,050	1,556,300
			<hr/>	<hr/>
			8,665,400	11,486,350

DRAINAGE INTO THE OCEANS.

PACIFIC OCEAN DRAINAGE AREAS.

Eural-Asia,	3,011,100	3,991,400
North America,	1,410,650	1,869,850
South America,	330,050	437,450
Australia,	210,300	278,750
Tasmania and New Zealand,	102,200	135,500
Borneo, Celebes, New Guinea, Philip-	619,150	820,750
pines, etc.,		
	<hr/>	<hr/>
	<u>5,683,450</u>	<u>7,533,700</u>

INDIAN OCEAN DRAINAGE AREAS.

Africa,	1,588,800	2,106,050
Madagascar,	178,150	236,150
Eural-Asia,	2,354,000	3,120,300
Australia, Tasmania, New Guinea, etc.,	928,750	1,231,100
	<hr/>	<hr/>
	<u>5,049,700</u>	<u>6,693,600</u>

ATLANTIC OCEAN DRAINAGE AREAS.

	Square Geographical Miles.	Square English Miles.
Africa,	3,095,800	4,103,650
North America, West Indies, and New- foundland,	2,508,800	3,325,500
South America,	4,611,600	6,112,900
Eural-Asia, and Iceland,	540,300	716,200
Do. (Baltic drainage area),	461,450	611,700
	<u>11,217,950</u>	<u>14,869,950</u>

MEDITERRANEAN AND BLACK SEAS DRAINAGE AREAS.

Africa,	1,141,950	1,513,700
Eural-Asia,	1,071,850	1,420,800
	<u>2,213,800</u>	<u>2,934,500</u>

ARCTIC OCEAN DRAINAGE AREAS.

Eural-Asia,	3,668,250	4,862,450
North America and Greenland (includ- ing Hudson's Bay area),	2,830,050	3,751,350
	<u>6,498,300</u>	<u>8,613,800</u>

SUMMARY.

Total Inland drainage areas,	8,665,350	11,486,350
Indian Ocean do.,	5,049,700	6,693,600
Pacific Ocean do.,	5,683,450	7,533,700
{ Atlantic Ocean (and Baltic) drainage areas,	11,217,950	14,869,900
{ Mediterranean and Black Seas drain- age areas,	2,213,800	2,934,500
{ Arctic Ocean drainage areas,	6,498,300	8,613,800
	<u>39,328,550</u>	<u>52,131,850</u>
Antarctic Ocean drainage (Antarctic Con- tinent),	2,689,850	3,565,550
	<u>42,018,400</u>	<u>55,697,400</u>
{ Atlantic Ocean, etc., area,	11,217,950	14,869,950
{ Mediterranean, etc., do.,	2,213,800	2,934,500
{ Arctic Ocean, do.,	6,498,300	8,613,800
Total Atlantic drainage,	<u>19,930,050</u>	<u>26,418,250</u>

According to the foregoing calculations, it will be seen that the total land of the globe occupies 52,131,850 square English miles, which agrees fairly well with previous estimates. This is, however, exclusive of the Antarctic Continent, of the existence of which we have now abundant proof.¹ The *Challenger* dredgings show that the rocks which are strewn over the bottom of the ocean to the northward of the icy barrier, must

¹ See map of Antarctic Regions in this month's *Magazine*.

have come from a very considerable extent of continental land ; they consist of the following lithological types—granitites, quartziferous diorites, schistoid diorites, amphibolites, mica-schists, grained quartzites, and earthy shales. These rocks and their broken-down components made up more than three-fourths of the deposits close to the icy barrier, and they can be traced in gradually diminishing quantity as far north as the latitude of 40° south. When over 150 miles from the Antarctic land or icy barrier, the Pelagic shells and frustules of the deposit begin to predominate, so that at a latitude of 60° south the *Challenger* found seventy-five per cent. of the deposit composed of Diatoms, Radiolaria, and Foraminifera shells, which had fallen from the surface waters. Wilkes, Ross, and Hooker record similar deposits and rocks from various points around the South Pole not visited by the *Challenger*. We may assume, then, that there is a very large mass of continental land at the South Pole. I estimate that its extent is slightly greater than that of Australia. If we were to regard as land all within 50 miles from the margin of the high icy barrier, rising from 50 to 200 feet above the sea, it would be considerably greater than Australia. The unexplored regions of the Arctic are most probably all or nearly all sea. Adding the Antarctic continental area then, as will be seen by the above figures, brings the total area of the land on the surface of the globe to 55,697,400 square English miles, or 42,018,400 square geographical miles—equal to about three-elevenths or four-fifteenths of the surface of the sphere. The area of the land, then, is to the water as 1 : 2.535864.

The Inland Drainage Areas occupy 11,486,350 square English miles, or about three-seventeenths of the total land. In these areas the deposits now forming take place in fresh or salt water lakes which have no connection with the ocean, or consist of formations arranged by the winds and rains, in temporary or seasonal lakes or rivers. In these areas no marine deposits can, of course, be formed at the present time, but formations such as are now forming in these inland basins are abundant in the geological series of rocks. The only contribution which these areas make to marine deposits is in the form of dust and sand, which are frequently carried high into the air, and far out to sea. Such wind-borne particles can be distinctly traced in the deposits of the North Atlantic many hundreds of miles off the west coast of Africa, and also at similar distances off the coast of Australia.

The land draining into the Atlantic Ocean, together with the Arctic Ocean, Baltic, and Mediterranean, which all communicate with it, has an area of about 26,400,000 square English miles, while the land draining into the Great Pacific Ocean is only 7,500,000 miles, or a little over one-fourth of that draining into the Atlantic. The land draining into the Indian Ocean is a little less than that into the Pacific. These facts account, in a very large measure, for the deposits of the Atlantic having a more terrigenous character, even many hundreds of miles from land, than they have in the Pacific at similar distances from the continents.

While the great bulk of the sediment brought down to the ocean is deposited soon after the mixing of the river and sea water, there is little doubt that in the Atlantic at least, where currents are more rapid and floating ice reaches a low latitude, some of the finest particles are distributed much more widely than in the other oceans. The dust carried by atmospheric currents from the continents likewise affects the deposits more than in the Pacific, Indian, or Southern Oceans.

A very large number of rivers pour their waters into enclosed and partially enclosed seas, and thus produce a state of matters in many of these differing widely from what obtains in the open ocean. Between $\frac{5}{13}$ and $\frac{6}{13}$ of the total land drains into such basins as the Black Sea, Mediterranean, Baltic Sea, Red Sea, Persian Gulf, Gulf of California, Gulf of Mexico and Caribbean Sea, the Yellow Sea, and other seas along the eastern coasts of Asia, and to these may be added the Arctic Ocean. Very little of the sediment brought down into these basins reaches the great oceans, and what does reach them must be the very finest material, except where the sea is affected by floating ice. It is consequently found that the deposits have very rarely a truly oceanic character in such basins. They are mainly made up of debris directly derived from the continents, while calcareous Pelagic shells, the siliceous frustules of Diatoms and Radiolaria, and highly altered volcanic debris constitute a very small percentage of the sediments.

In the case where very large rivers, such as the Amazon, the Congo, and the Plate, debouch directly into the open sea, terrigenous deposits, like those of enclosed basins, are pushed a long way out into the great ocean basins. On the other hand, we find along bold coasts, such as around the Cape of Good Hope, where few rivers enter the sea, the deposits have a Pelagic character close to the borders of the continents; and resemble the ancient greensands.

While the terrigenous deposits are formed principally from the solid matter borne down by rivers in suspension, the Pelagic or deep-sea deposits are chiefly derived from the matters borne to the ocean in solution, through the agency of life, or of materials which have undergone much alteration through long exposure to the action of sea-water, as in the case of the red clays.

The bearing of these investigations, in the apparent absence of truly deep-sea deposits from the geological series of rocks, will be at once evident, but the fuller discussion must be deferred till the areas occupied by the various kinds of marine deposits have been estimated. This will form the subject of a subsequent communication to the Society.

I have much pleasure in acknowledging the services of Mr. James Chumley in the planimeter observations, and in checking the calculations given above.