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Clements R. Markham C.B., F.R.S.

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THE LIMITS BETWEEN GEOLOGY AND PHYSICAL GEOGRAPHY.

By CLEMENTS R. MARKHAM, C.B., F.R.S.

(Read at the Meeting of the British Association, 1893.)

KNOWLEDGE is one, and its division into what we call sciences is necessary, because no human being was ever so gifted as to grasp it as a whole, and also to acquire a special acquaintance with all its parts. A division of labour is inevitable, and the bounds of each division must be more or less arbitrary. At the same time, there is no reason why those limits should not be fixed by common agreement, and upon grounds that would receive assent from expert and intelligent criticism.

In considering the boundary-line between geology and physical geography, I approach the subject as a geographer, and I look at it from a geographical point of view; but if my conclusions are in the main correct, they will be accepted by geologists, because, although our points of vision are not the same, the impressions we receive are caused by identical phenomena. From a central geographical position I believe that we may define the limits of our science, distinguishing between the subjects which are within our boundary and those which, although clearly belonging to another division of knowledge, are still pertinent to our inquiries.

I have no doubt of the utility of such definitions. While each seeker after knowledge should work within the defined limits of his own special science, it should also be his aim to generalise, and to bring out its relations with other spheres of inquiry. In both lines of study and of thought he will receive assistance from clear and acknowledged definitions of the scope of each science; for he will thus find guidance with regard alike to the methods and to the extent of his researches.

The first work of geographers is to measure all parts of the land and sea, and to fix the relative positions of all places on the Earth's surface. Locality is the basis upon which all human knowledge rests, and it is the priceless gift which geography supplies to her sister sciences. We first establish the locality, and then we study the phenomena within a given area, and the changes which have taken place during historical times; that is, the changes respecting which there is human testimony in some shape or form, not necessarily written testimony. These changes generally explain to us the laws according to which similar changes are now taking place around us. This is physical geography. From the point of view of its connection with physical geography, I take geology to be a study of the condition of the Earth, and of the changes that have taken place on its surface during the cycles of ages previous to the dawn of history. Sir Roderick Murchison used to say that the geologist was the physical geographer of former periods. When he studies the phenomena of physical geography, it is to collect data which will enable him to solve

some problem of remote ages. The geologist and the geographer use the same materials, but for different purposes; the former to find interpretations of problems relating to the past, the latter to explain what is actually taking place in the present. There is thus a definite boundary between the two sciences, although, as we have seen, each has occasion to use arguments derived from the other, in order to find interpretations or explanations for its own problems.

The physical geographer certainly has to learn from geology the influence that the nature of the various rocks and their present positions has had, and still has, on the features of the Earth's surface as we now see them. For instance, the causes which decide the direction of river-beds can generally be ascertained by a study of the nature of the rocks, and of their inclinations round the fountains and along the river-courses. But the objects of such study are different from those of the geologist; and no geological facts or arguments come within the sphere of the geographer's work unless they help to explain an existing geographical feature. The aid derived by the closely allied sciences from each other does not interfere with the enunciation of a distinct limit between them. I believe this boundary-line is to be found where human testimony ceases. Geography fixes localities. It finds certain physical phenomena peculiar to each locality, and it seeks for their causes. In such research the two sciences of geology and geography are on common ground; but while the object of the former is to obtain explanations of phenomena in the remote past, that of the latter is to seek reasons, from the testimony of history, for the condition of the locality as the geographer sees it before him. Generally such human testimony is sufficient for his purpose. When it is not, he seeks for explanations within the domains of geology, of biology, of botany, of meteorology, sometimes even of astronomy; but such necessity to go further afield does not vitiate the accuracy of a definition which sets proper limits to his own science. It merely reminds him of the great truth that knowledge is one, that it is one harmonious whole, and that the divisions into special sciences are the inevitable consequence of the limits which circumscribe the powers of the human mind. Humanity must acknowledge to itself that, as knowledge extends, these limits become more evident, and subdivisions become more urgent. In common with other sciences, geography finds the necessity for specialism, while the subdivisions within itself render clear definitions of its outer limits more desirable and more useful.

My own studies have been chiefly in the direction of comparative geography, and I have sought for the explanation of existing conditions of the Earth's surface by examining the records of former centuries. On the one hand, such special studies lead to an appreciation of the necessary connection between physical and political geography; of the fact that a consideration of the influence of the configuration of the surface, of climate, and of products must form the basis of a study of the history of man. On the other hand, they furnish explanations of the existing condition of the surface, and suggest that definition of the boundary between geology and geography which I now submit.

In order to test the application of a canon intended to define the

boundary-line of the two sciences, it will be well to select some given area for the purpose. The great valleys of the Ganges and the Indus will be suitable. If we go back to the earliest human records, we shall find that the inhabitable part was confined to the water-parting between the Jumna and the Sutlej. All the rest of the present valley of the Ganges was an arm of the sea. The vast region between Delhi and Calcutta has become habitable within the historical period. As dynasty succeeded dynasty, we find the foundation of cities recorded in situations lower and lower down the valley. The physical geographer compares the records of history with what he can now see with his own eyes. The process that is going on is described by Mr. H. F. Blanford. Standing on the banks of the Ganges, and watching the turbid flood swirling past, the observer sees the *chur* opposite, which the river left dry when its waters fell at the close of the last rainy season. Until lately it was covered by a rich green crop of indigo. It is now more than half cut away and buried beneath the waters. Huge masses detach themselves from time to time, and are swallowed up by the deep, muddy stream. These are present facts. The inquirer then learns that half a century ago the river itself was only a moderate-sized *khall*, and that an old channel, 7 or 8 miles off, and now little more than a string of pools, was at that time a great river. Turning to history, he will find that the ancient records of the people gradually unfold the causes and effects of what he has seen and heard. The positions of the capitals of the different dynasties which successively reigned in the valley plainly continue the story, until the Vedas are reached. Then the whole wonderful record is unfolded through the help of human testimony. It is all within the domain of geography, up to the causes which led to the drying-up of the Saraswati. The more remote record represented by the mountains bordering on the valley, by the Sawalakh hills and their fossils, belongs to geology. Here the reasons for drawing the boundary-line between the two sciences stand out clearly defined. All that comes within the ken of human testimony belongs to geography; the earlier pages contain the changes indicated by positions of strata and the story told by the Sawalakh fossils, and are a part of the science of geology.

If we come nearer home, we see how the remarkable phenomena connected with the long battle between the land and the sea at the delta of the Rhine teaches another memorable lesson in physical geography, with the aid of history. We see what is going on now; the dunes protecting Holland from destruction, the Zuyder Zee, the numerous islands, and the tracts of reclaimed land. Human testimony explains the causes which produced the present condition of this region and the gradual changes in the course of centuries. The slow movement of the dunes is revealed to us by the statue and temple of Nehalennia, which was uncovered some years ago on the Domburg Sands. A drive of 12 miles northwards from Bruges conducts the inquirer to the little country town of Sluys, which is surrounded as far as the eye can reach with cornfields and meadows and clumps of tall trees. The student of Froissart reads how our King Edward III. gained

a great naval victory over the French fleet on this very spot. If he continues his researches and studies the histories of the great struggle between the United Provinces and Philip II. of Spain, he will find that a change had slowly but surely been taking place. Sluys is still a port, but with very different surroundings from the Sluys of the 14th century. From that time he may trace its story, with the aid of a succession of maps, down to the present day. This is physical geography explained and illustrated by the aid of history. The earlier record of the same region, when the mouth of the Rhine was somewhere in the latitude of the Orkneys, and the river-drift men tenanted what was then a part of a continent, but is now the island of Britain, as distinctly belongs to geology. The interesting facts connected with it are not ascertained by human testimony, but by other methods and for other objects. Here again we find a natural boundary-line between geology and geography, by means of which the whole body of facts relating to a locality can be logically divided between the two sciences, and conveniently classified.

History, as well as the voyages and travels of former explorers, teaches many a fact of the greatest interest to the physical geographer. At the Pass of Thermopylæ he can study the topography of the Persian campaign, and fix the spot where Leonidas made his final stand; while at the same time he can trace the progress of the extensive changes in that region down to the present day. On the rock of Mont St. Michel he can watch the progress of the high tides until the place where he stands is converted into an island. History tells him that this mount, a college of Druidesses and later a temple of Jupiter, was in the centre of a great forest, the *Setiacum nemus*, in Roman times. Here, in this very county, the native of Nottingham may descend his own river of Trent, and come to a great cultivated district which was once Hatfield Chase, a wild tract of forest and moor, intersected by water-courses and dotted with large pools and swamps. The tomb at York Minster tells us that young Prince William, the son of Edward III., met his death in Hatfield Chase; he caught an ague while hunting deer, from a boat, in the marshes. In this instance the change is due to human agency, but that change is equally a part of physical geography, and the geographer traces its progress through the study of historical documents. Still more important changes have been caused in the countries bordering on the Mediterranean, partly through meteorological agents and partly through the work of man. In many places the cactus and the aloe have usurped the ground occupied in Classic times by forests of oak and beech. We know, from the evidence of historical documents, that the mountains bordering on the garden of Murcia in Spain, which are now naked rocks rising in peaks and ridges, were once, and not longer ago than the days of Alfonso the Wise, clothed to their summits with pine-woods.

It is thus that physical geography finds most efficient assistance from human testimony for the study of the former condition of parts of the Earth's surface at different epochs. It need not always be written testimony. The splendid temples of Selinunte on the south coast of Sicily, and the direction in which they have been thrown down, are the silent witnesses to a great earthquake in the eighth century. We have

seen, too, how the statue of the goddess Nehalennia explained the direction and rate of movement of the sand-dunes of Zeeland.

It is this testimony respecting the condition of the Earth's surface at long intervals of time which gives such importance to the editing and the study of old voyages and travels. Hence every physical geographer ought to be a member of the Hakluyt Society. By careful reading, and by knowing what he wants, he will pick many a plum out of the heaviest pudding. But, in truth, the quaint old narrators of voyages and travels are very rarely dull. The student of physical geography is sure to be rewarded by their perusal. He may be giving his attention to the formation of coral islands, and perhaps meditating on the question whether Bermuda once formed a great circle enclosing a lagoon. The existing evidence is the small west rock on the western reef gradually being reduced in size by the action of the waves. Further evidence of the dimensions of this rock in former times would be important. A man named Henry May went out as a mate with Lancaster in his first voyage to the East Indies, three centuries ago. May lost his ship somewhere near Puerto Rico on his return voyage, and took a passage home in a French vessel. He was shipwrecked on the western reef of Bermuda, and his journal supplies evidence respecting that west rock. He describes that land as consisting in his time of "high cliffs." Further research may reveal its dimensions at some other period, and so help the researches of geographers; for the narrative of Bermudez, the discoverer of this coral group, is still buried in Spanish archives.

When the explorer makes new discoveries, their true significance can only be established by the testimony of history. The region round Lake Zuway to the south of Abyssinia is almost unknown, and is consequently very interesting to geographers. It was unvisited for centuries, and Mr. Ravenstein, our greatest authority on Africa, has to go back to the enterprises of the Portuguese to find any traces of it. Thus it is that we appreciate the value of the narrative of Father Alvarez, who accompanied the embassy of Rodrigo da Lima to Prester John; for one of the members of this embassy, in a journey to the southward of Abyssinia, described the lake, which has again been revealed to us by modern travellers after an interval of three centuries.

Instances need not be further multiplied to prove that the alterations of the Earth's surface, which properly engage the attention of the physical geographer, rest upon human testimony—upon history and the records of voyages and travels. What applies to changes caused by the action of water, is equally true of the volcanic eruptions and subterraneous disturbances to which the surface of the Earth is subject. Some of these phenomena belong wholly to geology, while others have expended themselves in historic times, or are now actually at work. The great volcanic region of Auvergne belongs entirely to geology. Geography is merely concerned with it in reference to its actual physical aspects, and their relation to existing results. Its formation and history are beyond the domain of human testimony, and, therefore, of physical geography. The eruptions of Vesuvius, on the other hand, are purely geographical, although their study is important to geologists; because

the first appearance of activity took place in historic times, and its subsequent action is fully recorded. The same remark applies to the greater part of the mighty volcanic belt of fire from New Zealand to Japan.

Earthquakes compose another series of phenomena which belong to geology or to geography, as they occurred before or after the dawn of human testimony. Seismology is a department of geography, and the record of earthquake phenomena can only be completed by researches into the history of the past. The colonial records, in the Spanish archives, thus enable us to form a descriptive list of the earthquake phenomena on the western coast of South America for the last three centuries; and similar chronological series can be gathered from historical documents as regards several other parts of the world. In all these departments the line between geology and geography can be defined without strain or danger of confusion; and the result of the consideration of the question of limits, from this point of view, seems to be that it can be settled naturally and without undue concession on either side.

There are doubtless many other considerations which I have overlooked, and which should be marshalled in order, and be given their proper weight. This will be done in the course of a discussion; and the final event may modify or set aside my conclusions. I speak only as a comparative geographer, and from a special standpoint. Geologists may not improbably see the same facts from a different point of view, which will lead them to other conclusions. I believe, however, that such differences will only apply to details, and that a final conclusion may easily be reached by mutual concession. For we must recollect that, although knowledge is one, the limits of all our divisions of knowledge must inevitably represent a series of compromises.

Meanwhile, and until better instructed, I should define GEOLOGY as the study of the condition of the Earth and of the changes on its surface during the cycles of ages before the dawn of history; and I should define PHYSICAL GEOGRAPHY as a knowledge of the Earth as it is, and of the changes which have taken place on its surface during historical times. These changes, deduced from human testimony, explain to us the laws according to which similar changes are now taking place around us.

The two sciences depend upon each other and are very closely allied. The geologist finds the same phenomena in the rock formations of the past as the physical geographer discovers on the surface of the Earth of the present. Both, for example, have the duty laid upon them of seeking out the agencies which rule in the processes of upheaval and depression. The fold, with its crest and trough, is common to both sciences; and geographers have rejoiced at the announcement of "a wedding-ring of geology and geography uniting them at once and for ever in indissoluble union."

Mr. Markham's paper was read at a joint meeting of the Geographical and Geological Sections, and was followed by one by Mr. W. Topley, F.R.S., of the Geological Survey, in which the author admitted that physical geography is to a

large extent the foundation of geology, inasmuch as a geologist must study processes now in action before he can understand the manner in which rocks, now forming the Earth's surface, have been formed.

On the other hand, the existing surface features of the Earth can only properly be understood when viewed in relation to their geological structure. From this point of view geology is the foundation of physical geography. The range, shape, and character of these surface features are determined by the nature of the rocks and by the manner in which these rocks are arranged. Familiar illustrations of this point are afforded by the escarpments and valleys of England and France. It is equally apparent in the more complicated structure of mountains. The rocks of mountain ranges and their flanking hills are often contorted and inverted, so that the apparent succession is not the real one; but even here the surface features are equally controlled by the manner in which the rocks now lie. The existing surface of the land is almost entirely due to denudation; the manner in which this acts and the results developed vary with the nature and "lie" of the rocks.

The soils of a district have mostly been produced by the weathering of rocks, etc., at the surface. The soil, and the facility for obtaining water, have determined the original settlement of an area. The land divisions consequent on such early settlement have been equally determined, in many parts, by geological structure.

The discussion which these papers introduced contributed nothing of importance to the elucidation of the question.

THE RACES OF TRANSCAUCASIA.

By V. DINGELSTEDT,

Corresponding Member, R.S.G.S.

CENSUS.

THE Transcaucasian Statistical Committee has just issued a very substantial work on the population in Transcaucasia, containing figures appertaining to every nationality, every creed and every class of society, as also to their distribution in towns and villages. We see from it that in Transcaucasia thirty-five different nationalities can be distinguished, composed of thirteen or more races or family-groups, such as the Slavonian, German, Latin, Pelasgian, Iranian, Hindu, Semitic, Kartvelian, Finnish, Turkoman, and Caucasian strictly so called. The total number of the population in Transcaucasia is estimated at 4,702,898 (men 2,549,969, women 2,152,929). Subdivided according to their nationalities, they are distributed as given in the subjoined table, where their relative strength is expressed in percentages:—

Russian,	2·60	Tat,	2·65
Bohemian and Slovak,	0·02	Talyshin,	1·07
Pole and Lithuanian,	0·07	Kurd,	2·13
German and Swede,	0·19	Ossetian,	1·63
Moldavian,	0·03	Armenian,	19·96
Greek,	1·18	Gipsy,	0·02
Persian,	0·23	Hebrew,	0·73