A paper on the influence of clays and limestones on medical geography : illustrated by the geographical distribution of cancer among females, in England and Wales / by Alfred Haviland.

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When in 1868 I first carried out the design of illustrating the geographical distribution of diseases in England and Wales by means of coloured maps, I studied the registration district-map of England side by side with an early impression of Greenough's splendid physical and geological map of England and Wales, on a scale of six miles to an inch, published by the Geological Society. Those who know this map will understand how admirably adapted it is for the study of the physical configuration and geological structure of our country. Heart disease was the first cause of death investigated, and the results obtained proved how greatly the mortality from the class of diseases registered under this term was influenced by the configuration of the country; upon what is usually termed its physical geography. In fact the map of heart disease is eminently calculated to demonstrate the powerful effect on the public health of thorough ventilation by our prevailing winds; for it clearly shows that wherever these winds can have free access without hindrance, and can thereby purge all the valley systems of their residual air and malarial emanations — whether in the form of the source of malarial rheumatism or not—they thoroughly ventilate the country, and at once reduce the mortality from those causes of death grouped under the heading "Heart Disease." On the other hand, wherever the prevailing sea-winds are shut out from the valley systems in consequence of their axes being at right angles to their courses and the tidal wave—where, in fact, the valleys form pent-up hollows

through which these winds cannot blow—this map shows unmistakably that within such unventilated, or at least imperfectly ventilated, areas, are to be found the highest mortality from heart disease. Since this map was constructed, I have shown by later investigations throughout Scotland that the same rule obtains all over Great Britain, from the Land's End to Duncansby Head. I need scarcely say that the discovery of this important fact in the natural history of this class of diseases was wholly unexpected, although when displayed by means of coloured maps easily understood. So far such is an outline of the effect of physical configuration of the country on medical geography. We shall presently find, however, that the geological character of the areas under investigation must also be taken into consideration. Whilst pursuing the studies indicated above, I was struck with the close relation that the *high* and *low* mortality from some causes of death bore to certain well-marked geological features in the localities where these causes either prevailed or were infrequent. After completing my heart disease and phthisis maps, at the instance of the London Medical Society in 1868 I investigated the distribution of cancer among females in England and Wales, and whilst engaged in constructing the map illustrating the results, I became convinced of the close relation that the *high* and *low* mortality districts bore to the geological character of their areas. It became evident, after further investigation, which I have continued up to the present hour, that the medical geography of certain fatal malignant diseases among females, which have been certified by qualified English medical practitioners as *cancer* in some one of its forms, would be a valuable contribution to the natural history of that dreadful disease, not only because it showed a preference for certain haunts, which could be defined, but because it further showed that within those very haunts there resided a something associated with the presence and malignity of this dread disease which was capable of being influenced by certain geological formations; for it is evident to any one examining the map of the medical geography of cancer among females that the *high* mortality districts are always more or less associated with certain hydrographic and geological features, such as floods and clays; whilst the *low*

mortality districts are comparatively on high ground, not subject to floods, and mostly characterised by calcareous rocks. One of the functions of the medical geographer is to ascertain where certain diseases prevail, and to indicate those areas on his map as guides to other investigators who have opportunities of studying the causes of such prevalence on the spot, as well as others who are studying the natural history of such diseases, and especially those engaged in *bacteriology;* and lastly, to the busy medical practitioner who requires to know *at once*, for the sake of the patients who consult him as to where they ought not to reside if they would avoid the diseases they dread, and where are to be found the localities in which there is the greatest chance of escaping them.

The facts which drew my attention to this subject first were as follows: (1) In 1868 I showed, by means of the map of the Geographical Distribution of Cancer among Females at all Ages, during the ten years 1851-1860 (*a*) that the groups of districts having the lowest mortality from these causes were to be found where the *limestones and chalk* characterised the sites; and (*b*) that, on the contrary, the highest mortality was to be found where the clays of different formations abounded and were subject to be flooded by the *extravasated* waters of fully formed rivers. (2) In 1875, in the first edition of my work on disease distribution, I drew attention to the remarkable fact that cancer among women did not thrive in *chalk districts*, and referred to the infrequency of this disease where this formation predominated as follows:—"The essentially chalk county of Hampshire is remarkably free from cancer where this formation predominates; its rivers, the Test and the Itchen, have their origin in the chalk hills; they are genuine rivers of the chalk and possess these remarkable characteristics:—from the absorbent nature of the formation which gives them rise, they do not swell suddenly after heavy rains, nor do they flood their banks; they retain a very equable height during summer and winter, neither drying up in a drought nor flooding their vicinity after a deluge of rain or sudden thaws; their waters are seldom coloured — in fact they are the least alluvial of our rivers. We must, however, remember not to confound these rivers *from* the chalk, with those which only pass *through* the chalk, after rising from the heights of other formations, such as those

which spring from the Wealden heights, and then cut their way to the sea through the North and South Downs."*

When I first commenced these investigations I took the deaths at "all ages," and, even in the case of cancer among females, this was a necessary step in the first instance. My first map on this subject, which is now before the Congress, was constructed from the deaths among females at all ages that took place during the ten years 1851-1861. Cancer, however, among females does not begin to prove a very fatal disease until the age of thirty-five years is reached, as will be seen by the following table, which gives the death-rate among females at certain age-periods for the twenty years 1851-1870, to every 10,000 females living in England and Wales:—

Under 25 years ...	0·16	Annually to every 10,000 females living.
Between 25 & 35 years,	1·52	
„ 35 „ 45 „	6·34	
„ 45 „ 55 „	14·17	
„ 55 „ 65 „	20·92	
„ 65 „ 75 „	25.96	
„ 75 „ above	25·95	

And at and above 35 years for the same period 14.40 to every 10,000 women living. During the ten years 1851-1860, the death-rate for this period of life amounted to 12.98, whilst during the succeeding period it increased to 15.63. In this paper I shall deal with the twenty years period—1851-1870—except when I have reason to compare the first ten-year period with the second.

With the view of illustrating my subject I have selected certain groups of districts in three well-known parts of England:—

(1) The Thames Valley;
(2) The County of Hants; and
(3) The English Lake District.

I wish it to be understood in the first place that by the term influence I mean the power that clays and limestones have, by virtue of their physical and chemical natures, of

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* *The Geographical Distribution of Heart Disease and Dropsy, Cancer in Females and Phthisis in Females in England and Wales.*" Folio. Smith, Elder & Co., London, 1875, p. 87, a second edition of which is now about to be published by Messrs. Swan, Sonnenschein & Co., London.

strengthening or of enfeebling those factors in local climates which seem to be associated with the development of certain malignant growths that have been registered under the name *cancer*, as the causes of 92,935 deaths among females during the twenty years 1851-70. My maps show the death rates from this cause in each of the 630 registration districts of England and Wales, and it may be well to state at the beginning that during the twenty years cancer has never been absent from any one of these districts, so that whether a district be all chalk or all clay, it matters not—not one has been free from a fatal case of this disease.

It is a matter of fact that among plants we find certain species that really only *thrive* on *chalk* and *calcareous* soils, appearing every now and then in heavy clayey soils, and we wonder how these individual specimens found their way there, feeling sure in our own minds that their surroundings were not the result of choice nor in harmony with their instincts. Again, in our rambles we find a clay and moisture-loving plant every now and then rooted in a dry limestone soil, looking certainly out of place, and in a condition which we could not term thriving. Since land plants first appeared on the earth, some have been forced away from their ancestral homes to live as best they could on sites and amidst surroundings *toto cælo* differing from those of the homes where their early parents throve in ages past. Darwin has taught us with what results. With clays we associate impermeability to, and retentiveness of moisture; with limestones, on the other hand, dryness and permeability are connected in our minds. In geological history *life* dawned amidst surroundings in which carbon, oxygen, lime and water held sway (limestones), not where silica, alumina and water (clays) predominated. Nor was the dawn of life associated with the silica that formed the vast accumulation of sandstones. Every great geological period, from the Archæan to the Recent, has been characterised by either sandstones, clays or limestones. The Archæan rocks were subjected to decomposition and disintegration, and in the sequel yielded the material for Cambrian and Silurian clays, slates, grits and sandstones. Limestones appeared in the Bala and Coniston beds of the Lower Silurian; in the Cornstones of the Devonian; then followed the Mountain Limestone of the Carboniferous

period, the Magnesian Limestones of the Permian; and in succession, the Limestones of the Lias and the Oolite, and, lastly, the Chalk. The geological map before us gives us a picture of the sedimentary and other rocks with which these Limestones are connected in England and Wales. In the oldest rocks the clays are indurated, folded and changed by pressure and heat, and have lost their plasticity. They, however, are subject to *decomposition*, the action of sub-aerial influences, and under it return again to clay, which is washed down into the lower lands. The granites, too, which have been intruded into these rocks, where exposed by denudation, are subject to similar decomposition, and the hydrated silicate of alumina of their felspars forms clays which eventually find their level in the valleys.

If we pass on to the Mesozoic or Secondary period, we find the Lias yielding clays for bricks and tiles, the Bradford clay of the lower Oolite, the Oxford clay of the Middle, and the Kimmeridge clay of the Upper Oolites—the two latter are found crossing the valley of the Thames, in which also are found the Weald clay and Gault clay of the Cretaceous series, and the London clay of the Eocene, and covering the greater part of the valleys in the north of Great Britain is the Boulder clay. Clays and Limestones, therefore, are important factors in the structure of our country, and must, from their widely differing physical and chemical characters, be connected with widely differing effects on the lower air of our atmosphere, in which are found resident those invisible but potent influences which affect not only the cellular structure (both in its nascent and matured form) of the human body, but of all other bodies endowed with life that are bathed in it.

In the history of disease clays are connected with the most deadly scourges to which the human race has been subjected, such as those that have arisen in our own times from vegetable decomposition after floods—as in the instance of cholera from the alluvial clays forming the delta of the Ganges, and in the long list of malarial fevers all over the world which have had their origin in the deltas of rivers and inland marshes, characterised by alluvial clays saturated with the products of the decomposed and decomposing vegetation, that had first been flooded, then killed, and lastly, left to rot in the sun. Limestones have no such

an appalling record. We know of no epidemic sweeping over the world, either air-borne or man-borne, that could be traced to a limestone nidus; on the contrary, as I have just said, they are associated with the earliest dawn of life; and now I will endeavour to show how they are entitled to be considered as preservers of that life in contest with one fatal class of causes which imperil it.

The materials of the crust of the earth consist of between sixty and seventy bodies, which have been termed *elements*, of which those that form the bases of clays and limestones, namely, *aluminium* and *calcium*, formed 10 and 4·5 per cent. respectively, and when united to oxygen, forming alumina, amounted to 19·0, and forming lime, to 6·3 per cent. I have said that the physical and chemical properties of clays and limestones differ widely from each other, dwelling, however, only on the former. I will now, however, say a few words on an important property possessed by limestone, that is not found in any other rock —the power of neutralising the acids that are the result of vegetable decomposition.

We are well acquainted with the fact that the carbonic acid in rain water, by combining with the insoluble carbonate of lime, forms a soluble bicarbonate which is carried off to the sea in vast quantities by our rivers. We know, too, that the solvent action of rain water containing carbonic acid has been the cause in ages long past of the tunnelling of limestone areas, by which means underground rivers have drained the land—instances of which are recorded by the Greek poets, and by the geologists of the present day who have described the fossil-bearing caves of our country and of North America. In one of the limestone areas of the English Lake district may be seen, on a gigantic scale, the result of this solvent action of rain water, combined with that of acids, the outcome of vegetable decomposition. At Whitbarrow, in the Kendal District, the tilted slabs of limestone are seen to be sculptured in the most remarkable manner. The combined acids have eaten away the rock so as to form deep groovings all over the surface of the slabs; these groovings resembling the tortuous sculpturing known to architects as *rustic work*. Lying at the bottom of these snake-like grooves are the remains of the fallen leaves from the adjacent wood—sodden, decomposed and decomposing, supplying fresh acids by which the already deep etchings

are rendered deeper and deeper. Again, the joints of the limestone slabs are eaten away in a similar manner, so that they are now wide enough to admit a man's leg in many places, and the gaping chasms render great caution necessary in walking over this weird sculptured pavement. It is evident from what has just been described that the limestone has neutralised the acids that have been formed by the vegetable decomposition, which first took place at the surface of the slabs; and that the drainage of the carbonated rain water, rendered more acid by vegetable decomposition, first marked out the courses of the flowing acid water, so in the sequel were these courses preserved until, by gradual deepening, they were able to afford shelter to the blown leaves that fell from the trees around, until they were piled up in rotten masses of acid-forming material.

The great lesson that this interesting locality teaches us is that one of the chief functions of limestone is to *neutralise* the acid products of vegetable decomposition, and that this function is more or less well fulfilled whenever it is required; that it matters not whether the evil to be counteracted arises from a mass of dead leaves lying sodden on its surface, or from the results of a widespread flood covering many square miles.

I will now give you the facts which have, in my opinion, a special bearing on the influence of *Clays* and *Limestones* on the geographical distribution of *cancer* among females as an illustration of the subject.

(1) The Thames Basin.

In 1868 I constructed the map that I now exhibit, showing the geographical distribution of cancer among females at "all ages" during the ten years 1851-60. In that map you will find that certain areas are coloured in different shades of *blue*, the darkest blue representing the highest death rate from this cause, whilst the other areas are coloured in different shades of *red*, the darkest red indicating the lowest death rates. In the Thames Basin there will be found five groups of districts which follow the river in its course, and are either bounded or traversed by it. The highest group (1) consists of districts below Oxford, more or less characterised by clayey soils and subsoils; superadded to which are alluvial clays and river gravels. This group consists of the following districts—Wallingford, Bradfield, Reading,

Wokingham, and Henley—and in the map before you are coloured *blue* so as to indicate a death rate from cancer *above* the death rate of England and Wales for 1851-60. (2) The next group consists of Cookham, Windsor, and Wycombe, or such districts as are remarkable geologically for the outcrop of chalk that takes place within them, this formation, which is a carbonate of lime, prevailing over the greater part of the area which forms the group. Coincident with this geological fact is the medical one, that within this area the death rate from cancer was *below* the annual average of the country. This group is coloured red, indicating that it is a *low* mortality group. Between this group, which hereafter will be known as the Chalk group above London, and London itself, is a third (3) group consisting of Kingston, Chertsey, Richmond, Brentford, Staines, and Eton—all more or less lying upon the London clay. It is coloured *blue*, and contains a mortality *above* the average. (4) The fourth group consists of the Division of London and the districts of West Ham and Romford; this also is a *blue*, or *high* mortality group. (5) And lastly, below, is the group comprising the districts of Orsett and Dartford, both of which, like No. 2, are remarkable for the outcrop of chalk which takes place in them, the river Thames cutting it in two. This is known as the Chalk group *below* London, and is coloured *red*, indicating the *low* mortality within it. The areas of all five groups are more or less subject to seasonal floods.

On looking at the map, and seeing these two *red* groups standing out as notable exceptions to the other three *blue* groups, we are at once forced to ask the question: What is the meaning of such a marked difference in the mortality? or at least to inquire more fully into the circumstances which are coincident with two such sudden departures from the prevailing death-rates along the banks of the Thames. We then take a geological map of England and Wales, and compare the death rates from this cause in other parts of the country, and having discovered that chalk is the geological formation which is coincident with this lowering of the death rates in the Thames basin, we trace this formation and its allies, the Carboniferous, Oolitic and other Limestones throughout the length and breadth of the land, and then we find that, almost without exception, the districts which are similarly characterised by Chalk and Limestone

are coloured *red*, so as to indicate death-rates from cancer among females *below* the average. We next trace the different kinds of *clays* in the same way, and find that, wherever these formations are found, and subject to be flooded seasonally, as the districts of the Thames are, the districts which lie on these clays are coloured *blue*, indicating *high* mortality. There must be a cause for all this, but this I must leave for future discussion, as my present function is simply to lay before you the facts connected with the influence of clays and limestones on medical geography.

Before proceeding to the other groups, I will briefly summarise the facts as I have found them in the five groups of districts along the river Thames, as shown in the coloured map before you for 1851-70. I must now tell you that I have ceased to use the statistics of cancer among females at "all ages," for the reason that the table above (p. 6.) affords; by doing so I eliminate two-thirds of the female population which have not arrived at the age at which this class of diseases begins to show itself fatal. Necessarily in doing so the labour of the investigation is increased, but that matters not so long as the results are proportionately more reliable.

By that table we have seen that the mortality leaps from 1.52 at the age-period between twenty-five and thirty-five years, to 6.34 between thirty-five and forty-five years, and that it goes on increasing as age advances. Now, measured by the death-rates among females at and above thirty-five years of age, let us see whether another decennial period, added to the one represented on the map for 1851-1860, will bear out what seemed to be foreshadowed in it.

For the twenty years 1851-1870, the annual death rate from cancer among women at and above thirty-five years amounted to 14.40 to every 10,000 females living. We will just compare the death-rate notes of the two decennial periods separately.

Groups.	1851-1860.	1861-1870.
1. Clay ...	... 17.83	... 19.32
2. Chalk ...	... 12.41	... 17.26
3. Clay ...	... 16.95	... 18.57
4. Clay ...	... 16.68	... 19.44
5. Chalk ...	... 11.02	... 14.88

Clay groups ...	17.15 ...	19.16
Chalk groups ...	11.71 ...	16.07

For the two decennial periods, 1851-1870, the death-rates are as follows:—

	1851-1870.	Colours.
1. Clay	18.58	Blue
2. Chalk	14.97	*Red*
3. Clay	17.86	Blue
4. Clay	18.18	Blue
5. Chalk	13.08	*Red*
Clay groups	18.21	
Chalk groups	14.02	
Difference	4.19	

so that the death-rates on the chalk amounted to 22·9 per cent., less than those on the clays during the twenty years 1851-1870.

The chalk country of Hampshire will now engage us for a short time.

(2) The County of Hants.

In the map of deaths from cancer among females at "all ages" during 1851-1860, it will be seen that the group of districts drained by the rivers Test and Itchin is coloured *red*, so as to indicate a *low* mortality from cancer. The districts comprised within this group are Romsey, Stockbridge, Winchester, Alresford, Whitchurch, Andover, and Kingsclere, having a total mean population of women above thirty-five years of age of 13,551 during 1851-60, and 14,327 during 1861-70. In the former decennial period the annual death rate among women amounted to 10·06, and in the latter to 12·49 to every 10,000 women living. Thus we have the following death rates in a group of districts lying mostly upon *chalk* in Hampshire:—

	1851-60.	1861-70.
Hampshire group	10·06 ...	12·49
England and Wales	12·98 ...	15·63
Difference	2·92 ...	3·14

Compared with the clay districts in the Thames Valley we get the following results:—

	1851-70.
Thames *clay* groups	18.21
Hampshire *chalk* groups...	11·27
	6·94
Thames *chalk* groups with clay surroundings and floods	14·02
Hampshire *chalk* groups, chalk surroundings and no floods	11·27
Difference	2·75

(3) The English Lake District.

If we now take the English Lake district, we see, in the map already referred to, that the districts in 1851-60, which are chiefly characterised by the mountain limestone, had a very low mortality (coloured *dark red*), and that, on the other hand, the districts lying in the Valley of the Eden—where boulder and other clays prevail, where floods take place, and especially at the mouth of the Eden, Carlisle, where lias and other clays are found—that the mortality of the area was represented by blue so as to indicate a death rate above the average at "all ages." That the death rate too, in the Valley of the Derwent was higher than over the limestone districts. Such was the state of things at "all ages" in 1851-60. If we now look at the map which represents the geographical distribution of cancer among females in the English Lake district for 1851-70, it will be seen that wherever the mountain limestone and other palæozoic rocks are the characteristic formations, there the death rates are the *lowest*. As this subject will be fully discussed in the forthcoming second edition* of my original work, published in 1875, I will briefly give the following facts in such a form as to render them comparable with those already given:

The Cumberland, Westmorland and Lake Districts.

Mountain Limestone Districts	9·27
Clayey and Flooded Districts	15·71
Difference ...	6·44

* Swan, Sonnenschein & Co., Paternoster Square, E.C.

Before leaving these numerical data it will be well to place the main facts together, which the three groups afford us.

1851-1870.	Clay and Flooded Groups.		Chalk Groups.
1. London Basin...	18.21	...	14.02
2. Hampshire ...	—	...	11.27
3. The Lake District	15.71	...	9.27
Mean ...	16.96	...	11.55

These figures give us some idea of what has taken place all over the country, and are of a sufficiently decisive character to demand their being well weighed whilst studying the natural history of such a disease as *cancer*.

The difference in the death rates among dry and flooded districts is too evident to be passed by unheeded. The difference of over 30 per cent. is too striking not to demand investigation. What would the directors of a railway company do if they found a reduction in their profits of 30 per cent.? or rather, what would their shareholders do when they came to receive their dividends? Would they not ask, "How is this; this must be enquired into"? In the present instance, however, where human lives and not money dividends are to be enquired about, we find that, so soon as the facts were shown through the work referred to (p. 6), immediately after the resignation and subsequent death of Dr. Farr, means were taken to stop further inquiry at the General Register Office. These investigations are now entirely stopped in consequence of the present Registrar-General for England and Wales, in his supplement for 1871—1880, not having followed his predecessor's example in keeping the *males* and *females* separate in the 630 registration districts into which England is divided for the registration of births, deaths and marriages. It will hardly be believed that he has actually mixed up the deaths among the two sexes under the heading "persons," which renders the medical geography of fatal diseases among women an impossibility. In conclusion, I must call the serious attention of the members of this Congress to this remarkable defect in the present Registrar-General's supplement for the decennial period 1871-1880, and to ask them to express an opinion upon this departure from the model laid down by the late Dr. William Farr, C.B., F.R.S.

I believe that such maps as I have had the honour of submitting to this Congress tend to draw the attention not only of the student of demography and medical geography, but of the medical practitioner to the very localities where the causes of prevalence or infrequency of certain diseases are to be found. Such maps, too, in the practice of *preventive medicine* are indispensable, when the medical practitioner is asked the all-important question by patients predisposed to certain diseases, where they, their children, or those in whose welfare they are interested, similarly predisposed, should live, so as to give the dreaded malady the least chance of developing into a fatal form.