subject. Trade creates our wealth, and contributes most to England's greatness as a nation, and those who best conserve her interests are her most sincere friends. I trust the meeting will bear with me for occupying so much of their valuable time with these crude observations on what many may consider an unimportant subject; but its importance is frequently and deeply felt by those who have erected large manufactories, and those about to do so.

CONSIDERATIONS CONNECTED WITH THE RELATIVE CHANGE OF LAND AND SEA UPON THE SURFACE OF THE EARTH. BY CAPTAIN DRAYSON, ROYAL ARTILLERY, WOOLWICH.

There are few subjects connected with geology the accuracy of which have been so well established as that the land and the sea have frequently changed their relative positions. Upon first considering this subject, the mind is naturally influenced by a feeling of wonder and surprise.

If we stand upon some elevated snow-capped peak of the Alps, and survey the vast accumulation of ponderous rocks and towering pinnacles, heaped together in masses, or separated by yawning chasms, and then turn our eyes to the calm and verdant landscape beneath us and in the distance, it is really difficult to realize the truth of the statement that these lofty mountains were not only once level with the plains, but at no distant epoch were actually the bed of a sea. Fortunately the human mind is in the majority of instances guided by facts which, however strange or wonderful to our ideas at first, will still, after a lapse of time, be generally accepted and placed within the museum of science. Thus, when shells which were undoubtedly of marine origin, were found embedded in the solid rocks which formed the most elevated mountains, it was impossible, or at least
unreasonable, to deny the truth of the statement, that the
sea must once have covered these rocks. No sooner do we
become aware of this fact than we may discover that we
have lifted but one of the veils which conceal from us the
simplicity of nature.

To know a bare fact is in itself interesting; but to trace
effects to their ultimate cause, or rather to trace a succession
of effects, may lead us to perceive some of those wondrous
laws by which the machinery of the universe is regulated.
In the present inquiry we will start from the acknowledged
phenomenon that mountains now several thousand feet above
the sea level, were once beneath it; and we will direct
attention to the successive steps by which this result has
been attained. First, it is granted that a mountain, now
thousands of feet high, was once beneath the sea. It follows
then that either the mountain must have risen, or the ocean
must have decreased and passed away since.

It is now so generally known to all those interested in
geology, that facts prove that the mountains have been raised,
that we need not here enter into the proofs of this part of
the subject, but will advance to the next step in the inquiry.

It is found that not only are there mountains which were
once beneath the sea, but that there is land which is now
considerably beneath the level of the sea, and which was
once above it, and that submergences and emergences
must have occurred repeatedly. The alternate beds of coal,
sandstone, and shale, most clearly prove this change from
land to water. The first conclusion to which this fact
might lead us would be, that the same land had been forced
upwards from the centre of the earth, and had then sunk,
and so on, and thus that the change of water and land had
been produced by a process of oscillation.

To reach truth by means of inquiry, it is absolutely
necessary, in the absence of direct evidence, to consider by
what means the most evident phenomenon might have been accomplished, then to collect all the evidence connected with the effects, and lastly, after putting aside our preconceived opinions, to consider which of the many explanations is most in accordance with the actual facts before us.

To the scientific minds of the middle ages, few subjects appeared more unnatural and more ridiculous than that the earth should move. Yet actual facts were in favour of this movement. And these individuals forgot that whilst they rejected as absurd the theory of the earth's movement, they admitted as sound and probable, the theory that the whole of the fixed stars, the sun and the planets, rushed round the earth with a velocity a thousand times greater than that assumed by the new theory for the earth. Thus, it not unfrequently happens, that a truth, if novel to our minds, is rejected from its supposed absurdity, whilst a falsity which we have long tacitly acknowledged as a truth, is looked upon as quite in accordance with nature.

Whenever any change of level is spoken of, it is necessary to refer to some fixed point as a datum; in the present inquiry this datum will be the centre of the earth. That the same land should rise, then sink, then rise, and so on, is not by any means necessary to produce a change in the relative position of land and sea. Let us take an example: Suppose that the whole surface of Africa were to gradually sink, so that it approached 10 miles nearer the centre of the earth, (this distance being merely taken for illustration), in consequence of water finding its own level, there would be a transfer of a body of water from the whole ocean, equal in cubical contents to the area of the continent of Africa, and 10 miles deep. This withdrawal of water would leave a vast area of land, in many parts of the world where sea now exists,—such, for instance, as the Newfoundland bank, the English Channel, the plateau across the Atlantic, &c.
Again, suppose that Europe, Asia, and America sunk nearer to the earth’s centre by 10 or 12 miles, the whole bed of the ocean which was not covered more than 4 or 5 miles with water would then probably become dry land, whilst the now dry land would be ocean. If the then dry land were to sink whilst the then ocean beds were to remain stationary, the change of sea and land would be again produced. Thus, if these continued sinkings took place, all the changes of land and sea, which are visible on the earth’s surface could be accounted for.

Let us now take another view of the case. Let us suppose that at the present time the beds of the Atlantic and Pacific Oceans were to be forced upwards, and to the amount that the Alps were raised during a recent geological epoch. The water now lying above the Atlantic and Pacific beds would spread over the surface of the earth, and would cover the lowlands in various parts of the world, and would consequently cause these to appear as though they were sinking, whereas they might really be stationary as regards the central datum. All these changes, be it remembered, taking place slowly, but with varying intensity according to the causes producing them, a continued rise of the ocean beds would cause the whole of the dry land to be submerged, and a transferral of water to be produced. The elevation again of portions of the submerged continents would again transfer the water to other parts of the world; and thus, by a continued elevating process, all the changes of sea and land might be produced. It is highly improbable, that supposing either this or the former case to have occurred, that the continents would have risen, and in the same shape as at present. If either an elevating force be at work, or if there be a process of depression going on, then both these effects must have a cause, and this cause must work according to the conditions which produce it, the greatest force being
exerted when and where the conditions are the most favourable.

Thus the fact that land and sea have repeatedly altered their relative positions yields us a problem, which may be explained by three causes—

First. By an oscillation from and to the centre of the earth. Secondly. By a gradual but irregular contraction of the materials of the earth, particularly at the central parts thereof.

Thirdly. By a gradual expansion of the same materials. Either of the latter two suppositions may strike us as bordering upon the marvellous, but we shall require something very extraordinary to astonish us, if we bear in mind such facts as that the Himalaya Mountains, now 26,000 feet above the level of the ocean, were within quite a modern geological period the bed of a sea.

We will now examine the probabilities connected with the existence of these three supposed causes. Every effect must have a cause. If the surface of the earth has been elevated, the cause must be the action of some force from below, or some attraction from above. If the same surface become depressed, the effect must be caused by the withdrawal of this force, or by the action of a fresh and more powerful agent, and in a contrary direction. It is certainly more probable that some force has acted from below, than that an attraction from above has caused the elevation of mountains. To elevate such a mass as the Alps, the Andes, &c., the force, when measured by human ideas, must have been enormous; and this force must have consisted of some material power, such as the expansion of the dense masses deeply seated in the earth, or of some gaseous or steam-like force which had been generated in the interior of the earth.

It is almost impossible to conceive how any gas could act so as to sustain a range of mountains, even if we grant that
it could force them momentarily from their positions beneath the sea level. But if we suppose a mass of rocks acting from beneath by an expansive tendency, there is no difficulty in comprehending how a range of mountains might be forced upwards, and sustained there. When we consider the submergence of the mountains, we have a very difficult problem to explain. Mountains could not sink unless they had a vacant space into which to sink, and how is this vacant space to be obtained? We could only obtain a vacant space by assuming the withdrawal of the cause that produced the elevation; by the shrinking up of the rock that had expanded, if we grant an expansion, or by the perpetual shrinking, if we grant only the sinking probability. The sinking theory obliges us to make very many guesses and assumptions, and is more intricate than the elevation, which requires but one cause to be continued to produce all the effects. Assuming for a moment, that as the interior of the earth is of a density equal to nearly treble that of granite, there is an effort going on to relieve this density, then it would follow as a mathematical law, that the exerted force would act with the greatest intensity upon that portion of the earth’s surface which was nearest to the centre, and thus, other conditions being the same, that portion of the land which was at the time the bed of the deepest sea, would be acted upon with greater power than the land which was farther removed from the centre, and thus by a self-adjusting system the various portions of the earth would be raised in turn, and would become mountains, plains, valleys, or ocean beds, and thus the transferral of the water would be effected.

Geology, fortunately, is a science which rests upon facts, an examination of which will probably render us independent of mere probabilities, and may yield us some substantial evidence connected with the subject under discussion.
In consequence of various beds which were once contiguous having been elevated or depressed irregularly, it follows that the strata of which these beds are composed must be broken and dislocated. If the same strata have been repeatedly elevated and depressed, we should find that the various fractures produced all descriptions of forms and appearance without any regularity. The planes of cleavage would show signs of repeated rubbing and scratching, or the respective fractures would assume one form for *elevation*, and another for *subsidence*. If the surface soil has always sunk nearer to the earth’s centre we should have a larger area attempting to accommodate itself to a smaller surface, consequently there would be a lapping over of the various beds at the lines of fracture, whilst none of the lower deposits could ever come to the surface. First, because there must have been a contraction of the lower strata to admit of the upper sinking. Secondly, because the superficial area of the strata on the surface would, owing to the depression, have to arrange itself to the smaller superficies, and consequently there would be no opening for the lower strata to protrude through. If the surface soil has been continually elevated by the action of forces acting from the central portions of the earth, the various strata would be separated by short intervals, which would contain matter forced upwards from probably the expanded rocks themselves. Also there would be great horizontal distances between beds which were formerly connected with each other.

Now it is a well known fact that the planes of cleavage exhibit only one kind of action. Professor Phillips has observed this, and has mentioned in his Geological Treatise, page 40, vol. 1, that “an examination of the smaller and larger ‘faults’ where their planes can be clearly seen appears to show that only one kind of action has been impressed
upon the masses, as they appear to have slid in one direction, have been rubbed on their faces in one direction, and seldom if ever exhibit any signs of repeated action, along the same or neighbouring planes, we are forced to adopt as a highly probable view of their origin one continuous effort of a great force tending to extend and consequently inducing tension in, and fracture of, the crust of the globe." Thus the oscillation theory appears to be disproved by the appearance of the planes of cleavage; and if one force only has been at work, and if this force was an expanding force, then there must be a uniformity in the position of the beds where separated by "a fault."

The researches of inquirers connected with the peculiarity of faults, have shown that there is one almost invariable rule in connection with this subject, viz., that the fault invariably "hades," or underlies, in the direction of the downthrow, that is, if A and B are beds once continuous, they will always be found, at a fault, to lie as shown in Plate, fig. 1, and never as shown in fig. 2. It is therefore impossible for any bed to be brought vertically under another part of it, and thus no fault can bring a superior bed under one originally below it.

As a corollary to the above, it follows that the alternate change in land and sea must be caused by one continued elevating process, acting from the interior of the earth. In addition to the evidence afforded by the faults, we have the proof of a force acting from below in the intrusion of trap rock, &c., which has been actually forced to the surface through the openings consequent upon an elevation of the upper beds. If, then, we were to attempt to fit together the now disjointed strata, we should have to place them upon the surface of a sphere of smaller dimensions than is our globe, or there would be vast chasms separating the various portions.
A GEOMETRICAL PROBLEM CONNECTED WITH THE ABOVE.

—A very simple, but at the same time a very interesting geometrical problem is submitted in connection with the faults, viz., If there be a horizontal separation between two beds, what amount of elevation has caused this separation? See Plate, fig. 3.

This question is solved as follows:—Suppose B A C a portion of the earth, C the centre of the earth, A B a portion of the surface, which has been raised from the position X Y by the action of expanding deposits at F? The question is, to find the distance X A, that the strata has been raised.

Suppose the distance A B to be 10 miles, and that in this distance the various beds have been separated in horizontal distance a total amount of 50 yards. Then taking C A, the present radius of the earth to be 4,000 miles, A B to be 10 miles, X Y to be 10 miles, less 50 yards, we should have the following proportion:

\[ \frac{C A}{A B} = \frac{C X}{X Y} \]

Thus C A, A B and X Y being known, we can find C X, which in the present example would enable us to find that A B must have been raised 11 miles at least to produce a horizontal separation of 50 yards in 10 miles. This amount, although apparently large to us, is still not one six-hundredth part of the thickness of this globe, and would be comparatively as insignificant as one-tenth part of the thickness of the peel of an orange, to the orange itself.

From the above problem we could, if given the horizontal distance between two sides of a fault, immediately find the amount of elevation which had caused it.

It is to be hoped that those geologists who devote their time to collecting details and facts, will give some more information than at present exists, connected with the horizontal distance separating the various beds. Whilst a
considerable amount of attention has been directed to the
dip of the beds, and the distances vertically of the upcast
from the downcast, there appears a deficiency of published
information connected with the horizontal distances, or with
the horizontal extent of the fissures into which trap rock, &c.
has been forced. Yet this information must lead to the
most important results, if we consider the causes of a
phenomenon to be as well worthy of philosophical inquiry
as is the evident phenomenon itself.

Sir R. Murchison mentions in his work, "Siluria," that
there is a fault near Wolverhampton, which is 140 yards
wide; and in the same work he mentions several which
are of great width.

To test this matter thoroughly, it requires that the dip
of the beds on each side should be measured, as well as
the horizontal distance between the fractured ends. The
horizontal distance of the beds would then require to be
divided by the cosine of the angle of dip, to obtain the true
horizontal distance of the beds, and hence the horizontal
extent of the fault, after which the amount of elevation
might be easily calculated by the following formulae:—

\[ CX = \frac{CA \times XY}{AB} \quad \text{and} \quad AX = CA - AX. \]

Where \( CA \) = present radius of Earth.
\( AB \) = present length of strata + the horizontal width of fault.
\( XY \) = length of strata — fault.
\( CX \) = former radius of earth.
\( AX \) = elevation of strata since deposition.

PROBABLE CAUSES.—We will now consider the probable
causes which have produced the elevations shown by the
evidence of the faults, intrusions, &c., to have actually
occurred.

To cause vast portions of the earth’s surface to be raised
from the direction of the centre, it is necessary that the
masses of matter lying deep down in the centre of the
earth should by some means be caused to occupy a larger space than they formerly did. In what manner could this tendency to expand be induced?

If we examine a common pebble, or stone, we must be aware that this is composed of various particles, which are held together by some mysterious power. If we direct our attention to a piece of granite, we must come to the same conclusion; yet the granite, bulk for bulk, will probably weigh much more than the pebble. That power, or force, which attracted and held together the particles composing these two substances, must have acted with a diminished intensity, or for a shorter period, upon the particles composing the pebble than upon those composing the granite, or these pebbles would not be composed and arranged differently. What then is the power which has acted with a varying intensity on these substances? By what means was it produced, how may it even now be working, or what are the laws regulating it? Alas, we are reminded that science is but yet in its infancy, and that we live in the age of names. We speak about attraction, repulsion, electricity, magnetism, gravity, and other things, just as a Caffre might talk about the moon, the sun, the stars, &c.; and we know as much of the actual components of these forces, or of their real nature, as does the savage of the celestial bodies. It is true that we know some of the effects of gravity, electricity, &c., just as the Caffre knows that the sun shines, and that the stars twinkle, otherwise we have our unknown, just as he has his. There is, then, some unknown, although named, power, which has caused various substances to differ in the approximation of their component parts.

We find that the whole earth possesses a density equal to five and a half times that of water, consequently the particles of matter near the centre of the earth must be held to each other very closely. Is there any tendency on
the part of this attracting force to decrease in intensity, becomes a fair question? If there be, then its action upon these dense and central portions would cause an expansion in the mass, which expansion would cause the elevation of the surface, and the forcing up of any matter which might be in a fluid state above the expanding mass. We know as a fact that heat will cause an expansion in almost all substances, that is, that heat will cause the particles to separate in a measure from each other, the amount of separation depending on a law, the details of which are unknown. Thus, if there be any such tendency on the part of the lower strata, we have an adequate cause for the expansions mentioned above.

Let us now consider another question. Heat produces expansion in almost all substances: might not the exposure of the earth to great heat cause a considerable elevation of land by means of the expanded strata? Certainly this result might follow; and if we could see a means by which an additional amount of heat might be obtained by the earth, we should not be supposing a cause which was itself inexplicable. We must at this point entirely separate our ideas from that vague indefinite cause spoken of as the central heat theory, which assumes that the earth at a short distance beneath the surface is in a state of fusion from intense heat. There is not a well established fact of any kind to prove this assumption, and there are very few facts in geology which are explained even if we grant the truth of the theory. This theory about the centre of the earth being in a state of fusion from heat is based upon the fact that if we descend into the earth we find a greater heat than upon the surface. Surely this is a very slight foundation upon which to build so singular a supposition. Yet this theory is assumed by many individuals to be so firmly established by facts as to be unquestionable.
It has often been remarked that that which has been unquestioned, need not be unquestionable. But let us take an example:—Suppose that we placed a cold 68lb. shot in front of a fire, and caused this shot to rotate for about half-an-hour, we should then have the surface the hottest part, whilst the centre would be quite cold. Then suppose that we removed this shot from the fire, and swung it about in a cold air, the surface would then get cold before the lower portion, in consequence of the radiation of the heat. Thus if we were to examine the metal at a short distance from the surface, this metal would increase in heat up to a certain distance, but it would again decrease, until it became quite cold near the centre.

What then should we consider the value of the conclusion, which at once affirmed that because the heat increased from the surface of this shot to one-tenth of an inch from the surface, that therefore the centre of the shot must be red hot. Most surely this would be too hasty a theory. Yet this is the only evidence which leads to the conviction that the centre of the earth is in a state of fusion from heat. Heat will explain much in geology, but it must not be a heat in the centre of the globe, nor can a cooling globe explain any of the geological facts, for contraction follows cooling, and direct evidence speaks to expansions only.

A powerful telescope being directed to the planet Venus enables us to perceive that some very singular conditions prevail upon her. She is spherical like the earth, she rotates on her axis, she revolves around the sun, she has an atmosphere, and, in fact, appears very like our globe, except that a singular annual variation of climate prevails upon her surface. If Great Britain were transferred to the same latitude on Venus that it occupies on our earth, we should have an arctic climate in winter, during which the sun would be absent nearly 40 days, and thus Scotland, Wales, and
England would have their glaciers and icebergs formed in winter. In the summer, however, there would prevail a heat of which we have no conception. The sun would then return, and would remain 40 or 50 days entirely above the horizon day and night, not low down as is now the case in the arctic regions, but nearly vertical both day and night. Those only who have felt the fierce heat of a tropical sun, which remains scarcely more than 12 hours above the horizon, can imagine what would be the intense furnace-like heat, were the sun to remain nearly vertical during 40 days and nights. The rocks on the surface, and even deep down in the earth, would become heated beyond anything which we have ever seen, whilst the sulphurous strata would be forced into a volcanic condition. These and many other changes are probably occurring in Venus, for it is a fact that on that planet the sun does so remain above her horizon.

This singular climate is the result of the axis of Venus being inclined at an angle of only 15° to the plane of her orbit. From the consideration of the conditions on Venus, we naturally turn to the evidence afforded by geology on our own globe. We read about the singular climate of the glacial epoch, when glaciers extended down to 35° of latitude, and when huge boulders were carried from and to various parts of the world. The actual conditions now enacting on the planet Venus, dovetail very singularly with the evidence afforded by geology on our own earth. The intense heat of the sun during about 40 or 50 days, would certainly produce great heat in the earth, and even to the depth of some miles, especially if this condition prevailed during several thousand years. Surely we should have an expansion going on in Venus; mountains would be raised, fusion produced, and a heat induced in the lower strata just as there would be in the 68-pounder exposed to the fire.
In conclusion, therefore, we venture to point out that there are three methods by which the alternation of land and sea might be produced. That the greater number of facts point to a continued elevation of land by means of forces acting from the interior of the earth as the cause. That an examination of the fractured strata will show to what extent the elevation within modern geological periods has amounted. That there is no difficulty in finding a cause for the production of an elevating force, when we consider the density of the central portions of this globe, and believe it possible that this density may be decreasing. Or if we examine the other members of our system, and consider the conditions now transpiring upon their surfaces, and then find that there is a movement of our earth which appears to tend to the manifestation of the same conditions.

In a short paper like the present, it is difficult to do little more than glance at the probabilities which we have had the honour to submit to the meeting. Nor is there time to discuss the value of the objections which may be urged against the views here put forward.

Thanking the meeting for their attention, we beg to request the favour of their consideration upon the matter contained in this paper.