Our Pulsating World
The Influence of Earth Movements on Human Development[1]

By

A. N. LEWIS, M.C., LL.D.

(Portion of a lecture delivered at the presentation of the Medal of the Royal Society of Tasmania to the author)

GEOPHILOSOPHY

It is very usual for people to say 'Things are not what they used to be—even the climate is changing.' Of course it is. Everything is changing. Change is the order of nature. Nevertheless, change and development in the vegetable and animal kingdom are very largely the result of changes on the face of the earth. This change is so gradual as to be imperceptible to human senses, but what we call 'the solid earth' is really a pulsating body, growing, discarding, developing almost like a living thing, and the results of each period of development lie around us, if only we will look.

We can now see an underlying principle or guiding influence emerging from the bewildering discoveries of science. This is the nature of the Earth itself—the mother of all living things, and, if we are to lead a really full life, we must be able to picture the Earth in its relationships to ourselves. After all, is this not true philosophy—the science of being—for out of the Earth all things have their being. Looking beyond individuals to species and wider groups of living things, we can see that they have not *grown*, but rather have been *brought up*. If our philosophy stops short of bestowing a consciousness on the Earth, that is only because our ideas are restricted by language. The result we see around us is in no way different from what it would be were we to accept the Earth as a conscious individuality. The conscious direction given by the human mind is, after all, a physical phenomenon, the result of influences dating back for hundreds of millions of years. The control of life by the Earth is also a physical phenomenon emanating from the same influences and, ultimately, the same force as the human mind. If we are to live fully we must have a philosophy of life. To serve us truly, our philosophy must be based on truth. The knowledge of the being of the world as a planet—what I have called *Geophilosophy*—must form the basis of our personal philosophy of our own life.

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[1] This lecture may be regarded as a summary of present geographical knowledge for the benefit of Tasmanian students, rather than as an original contribution to scientific knowledge of any general interest beyond Tasmania.—A.N.L.

Yet how much does the average person care? Of the thousands who daily look at Mount Wellington from our city streets, how many ever think, *how, when, why,* it stands as we see it. It is a real tragedy that there are not ten people amongst those who have ever seen it who have tried to fathom the riddle of Hobart's Sphinx. How much more true is this of our conception of the world as a whole. Unless you can hold the Earth in your hand and understand it as the living, pulsating, and dominating thing it is—can you call yourself a philosopher? The first lesson of science is proportion. When you can comprehend the sun as an infinitesimal atom of the universe rushing through space at 200,000 miles an hour, now twenty-five billion miles from its nearest neighbour, but nevertheless a member of the larger atom of creation—when you can comprehend the influence of the Earth, a minor planet upon the atoms which in their organized existence make up the microscopic creatures which live on its surface—then you will have no unduly exaggerated notion of the importance of your own daily troubles.

THE EARTH

Before we can form a reasonable appreciation of events on the surface of the earth, we must have an accurate idea of the nature of our earth as a planet. Modern science has gone a long way towards providing this. In the first place, the world is not a thin crust adjusting itself to a cooling interior. We have learnt much since Kelvin used the simile of the baked apple. For one reason, amongst many, solid rock (unlike ice) sinks in its molten equivalent, and, in cooling, the core of the earth solidified first. We must regard the earth as a mass of rock groups of varying nature, with the heaviest at the core, all under enormous pressure, which increases with depth, and all mutually supporting each other in a condition of adjustment, held together by a definite attraction and by great pressure from outside.

The mass of the earth is composed of a few common and many rare elements, which combined in the original cooling to form definite minerals. The minerals which consolidated first and heavy minerals consolidating somewhat later tended to congregate as a core. The earth in this way is now seen to consist of concentric rings of matter which increase in density inwards. The inner core consists of a substance resembling nickel steel (called by Suess *Nife*), with gold, platinum, and other heavy metallic elements. Outside this is a ring of iron silicates *(Sife)*, divided into eclogite and pallassite—our heaviest known rocks. Next come the ferro-magnesium silicates, or basalt rocks *(Sima)*, and, last of all, the alumina silicates, or granite rocks *(Sial)*. It will be noticed from Fig. 1 that the *Sial* is not continuous. Over the Atlantic it is very thin, and it is ruptured over the Pacific, Indian, Arctic, and Southern Oceans.

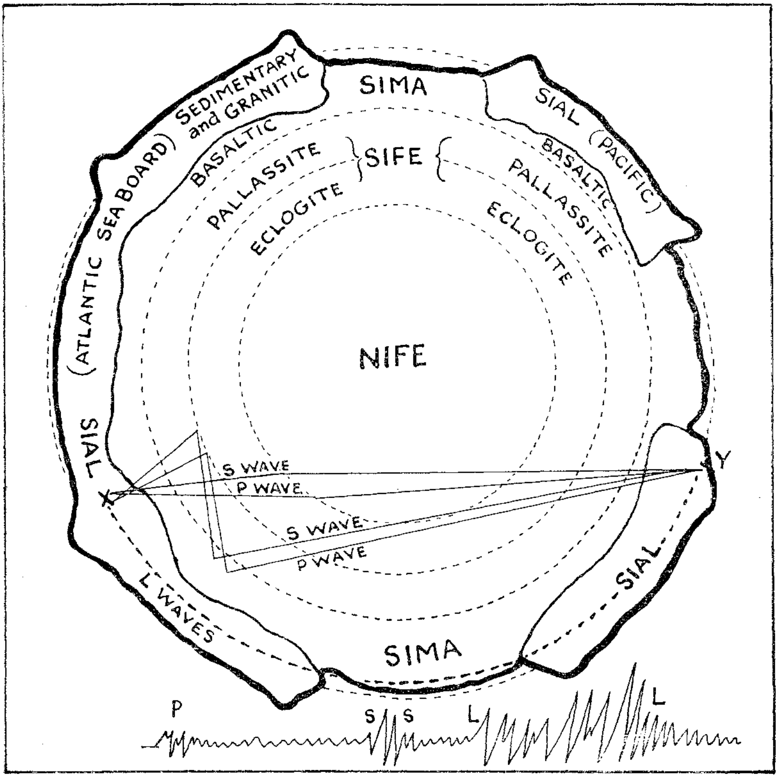

Fig. 1.—Diagrammatic Representation of the Interior of the Earth.
This shows the density zoning from the nickel-iron core (s.g. 7·5) to the basaltic layer (s.g. 3·5), with the light acid or granitic layer (s.g. 2·5) forming the land masses 'floating' in the basaltic layer. The Atlantic Ocean covers a depression in the granitic layer, and the other oceans cover gaps in the layer, having floors of the basaltic layer.
(NOTE.—The diagram is not intended to represent the reflexion and refraction angles of the earthquake waves, which are greatly exaggerated.)

The study of the behaviour of the seismograph when recording major earthquakes has provided a means whereby the nature of the interior of the earth may be studied. It is very noticeable that the instrument commences its record by a number of short, sharp vibrations (*P* waves). After an appreciable time a few waves of greater intensity are recorded (*S* waves). These gradually decrease until they are replaced by waves of maximum intensity (*L* waves), which reach a climax, and then decrease regularly until the instrument ceases to record. The earthquake shock produces wave motions similar to any other wave, and when such an impulse passes from one medium to another of a different density the original wave is split, portion being reflected back into the original medium, and portion passes to the new medium, but with a slight change in direction (provided, in both cases, the angle at which the wave meets the dividing line permits this). The *P* waves are those which pass direct from the epicentre of the earthquake *X* to the instrument *Y*. The *S* waves are reflected waves, of which there may be many, as several media are traversed. The *L* waves are those which travel round the circumference of the earth. When the epicentre has been located, and the distance thence to the instrument has been accurately measured, the time interval between the reception of the *P*, *S*, and *L* waves provides a means of testing the varying density of the rock through which the waves have passed. The rate of passage is constant, and is now known with great accuracy, and from the results of extensive researches it has been possible to determine the density, and consequently the nature, of the rocks composing the interior of the earth.

It is well established that the interior cores are very solid, more so than the best steel. They are certainly at a high temperature, so hot that they would fly into gases if at the surface, but they are under such compression that they maintain their rigidity. However, if the pressure is released, they will fuse, and they will yield to the slightest variation of pressure. The position is that the earth is only stable while the pressure from all parts of the surface on the interior is the same. When this varies, the interior yields, with the results to be described later. Thus, the lighter *Sial* may be regarded as floating on the *Sima*, somewhat as icebergs float on water. It cannot sink, as it is lighter, but it can squeeze portion of the *Sima* out between spaces in the disjointed blocks of *Sial*.

These blocks of *Sial* are the continents, and the spaces between them are filled with the lightest and most fluid constituent of the earth (water). These spaces represent the oceans, except the Atlantic, which is a deep trough in the *Sial*. The framework, or shields, of these continents were formed from the original *Sial* masses on the original cooling of the world. All that primordial material has now disappeared, but we can trace where it originally stood. This was the position when the world had first cooled sufficiently to allow water to remain on the surface. The surface was then covered by some 12 to 14 blocks of differing density, but all exerting an equal pressure on the interior, the difference in density being compensated by difference in height above the average surface. These blocks therefore interlocked and mutually supported each other, much as the stones of an arch.

But from the very first another factor was at work which tended to upset this adjustment—isostatic adjustment as it is called.

That factor was erosion. All day and every day the influence of weather and running streams is at work on every part of the surface of the globe which is not protected by the sea. The effect of this is that the lighter segments are continually being worn away and made lighter. All this eroded material is carried out to sea and deposited on the heavier segments, which are continually being made heavier. In the course of time this upsets the adjustment. The heavier segments cannot sink, in the normal sense of the term, because they are supported by still denser layers below, but they exert a cumulatively greater pressure on the plastic interior, and squeeze underlying material in the direction of least resistance—under the lighter segment alongside. That imparts a constant upward movement to the land, which in turn adds erosive power to its streams, and increases the load which is bearing down the neighbouring ocean floor. So we have a constant cycle of movement, as shown in Fig. 2.

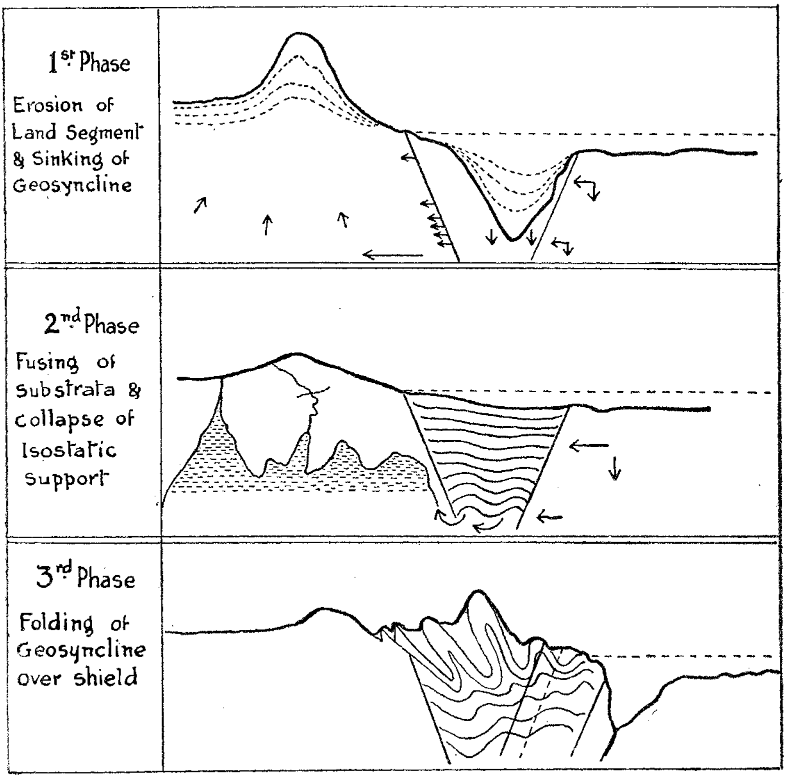

Fig. 2.—Diagrammatic Representation of an Epiorogenic Cycle.

However, since the earth is a sphere, any surface area must form a wedge downwards. Therefore any sinking generates pressure on the boundaries of the sinking segment. The land side of the wedge presents the less resistance, as it is less dense than the ocean segment on the opposite side. And here also the sediments are thickest and of a nature less able to resist pressure. As the process continues, the newly deposited sediments are squeezed up and over

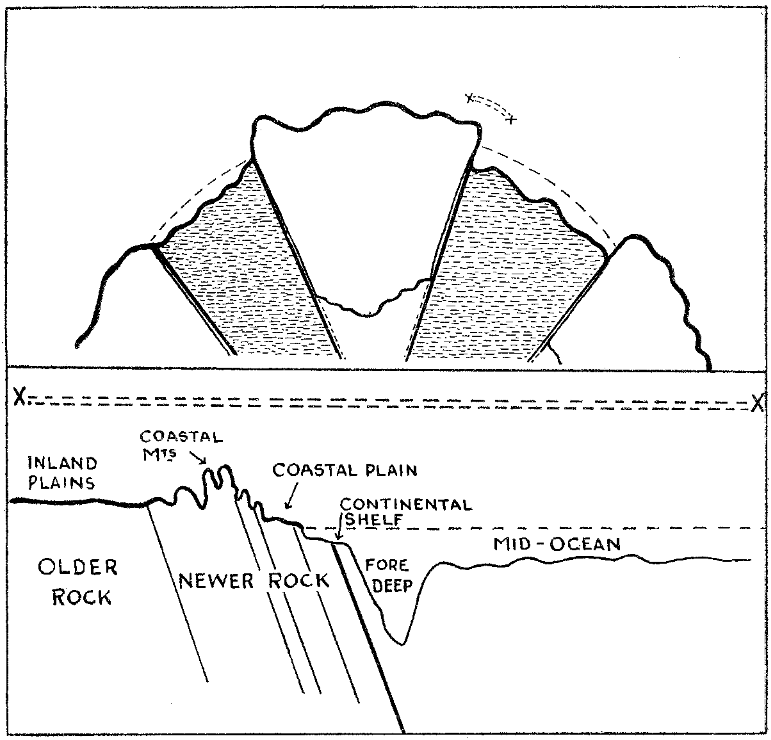

Fig. 3.—Diagrammatic Representation of the Process of Continent-Building.

The upper portion illustrates the effect of the sinking of a segment of the globe. X= = = = = =X is enlarged in the lower portion of the diagram, and illustrates the typical margin of the continents.

the margin of the older land mass, and so, in addition to the slow continental uplift, we get a more rapid movement, resulting in the formation of chains of folded mountains along the continental sea-board, with festoons of islands representing a continuation of the process out to sea. (Fig. 3.) All this generates heat from friction, and much of the underlying rock fuses and forms large deep-seated reservoirs of molten rock. This cannot withstand pressure as solid rock can, and the continental mass, in such circumstances, tends to collapse. This happening throws additional stresses on the wedge of newly formed sediments, and completes the process of the formation of great mountain cordilleras like the Alps, Himalayas, Rockies, Andes, &c. (Fig. 3.) It is often accompanied by intense volcanic activity.

The process continues until the pressure is mutually adjusted, and heat is lost by radiation from volcanic extrusions. Weather then commences again to destroy this adjustment. Rock masses are very rigid, and it takes a very considerable difference in stress to overcome this initial resistance. When, however, it is overcome a major world revolution occurs.

Radio-Activity

This cycle of adjustment, erosion, uplift, squeeze, collapse, and overfolding of a new zone of rock does not explain everything. There is a further, major pulsation caused by an inherent property of the earth. It is now known that the sun is not getting appreciably cooler. Neither is the earth. This is due to the existence throughout the matter of the sun and its planets of elements possessing what is known as radio-active properties. There are some 30 of these, grouped in two families—*Uranium* and *Thorium*. These minerals are constantly breaking down by the emission of electrically charged atoms of helium and other rays, which are ejected explosively with velocities of thousands of miles a second. You can see the result by examining a luminous watch with a magnifying glass in the dark. If the parent uranium constantly gives off helium, something else must remain. There are, in fact, eight stages, the third of which is radium after three atoms of helium have been discharged. After eight atoms the mineral becomes stable as, chemically, lead *(Ur pb* or *Th pb)*. This change cannot be hastened or retarded. The bombardment produces heat and also chemical change in surrounding rock. You all know the possibilities in this direction of radium.

Two results flow from this attribute of our planet. First, the constant bombardment of surrounding rock generates heat. This is the heat of the earth and of the sun—the difference bearing an exact ratio to the differing proportions of radio-activity in each. The cumulative effect is enormous, particularly as slightly radio-active minerals, such as zircon and orthoclase, are widely distributed, and the simple fact is that the earth is not cooling appreciably. The second result is that an accurate time-scale has been worked out from these minerals. The change is constant. It starts when the rock in which the mineral is found crystallized from a molten magma. The proportion of daughter elements to the parent uranium or thorium can be measured with great accuracy, and the date of the formation of the rock in question can be ascertained almost to a year.

History

We now know that the sun's heat is not due to combustion—it would not last for 1000 years if such had been the case. We also know that the climate of the earth was much as we now know it, 600 million—perhaps 1600 million—years ago. The fact is that the energy stored in the atoms which make up matter is sufficient for every requirement.

Astronomical data show that the sun has been shining much as it is to-day for 8 billion years, and that the planets separated about 3000 million years ago. The cause of this separation was, most probably, the near approach of a star which raised a tide on the face of the sun, some of which separated and consolidated into nuclei we now call planets. The moon must have separated from the earth at the same time. This date, 3000 million years, accords with astronomical, physical, and radio-active evidence.

Geological history is conventionally divided into certain epochs recognizable as lasting from one major orogenic revolution to the next, and marked by a distinctive grouping of forms of life. In the geological sense, these have been true revolutions—slow to the degree of imperceptible, but when completed, final and terminating a distinct phase of history. Some forms of life have persisted since the earliest times, but in each epoch there has spread over the world a group of more highly specialized forms, which have become extinct at the beginning of the next revolution owing to their inability to adapt themselves to the changed conditions.

Traditionally, geological history commences with the Cambrian period. Radio-active evidence places the middle of this period as 600 million years ago. But we now know that there was a period of 1000 million years prior to that when the world was subject to the same geographical influences as we now know. Therefore we have a period from the earliest times to the time when water was able to condense of some 1400 or 1500 million years, a period equal to the time which has elapsed between that date and the present time. Between the time when water commenced to run and the earliest records of geological history, vaguely termed the Pre-Cambrian, there elapsed a period of 1000 million years, far longer than the whole period about which we know anything. Geology, therefore, can at present only deal with one-fifth of the earth's history, and we must still rely on physics and astronomy for the earlier four-fifths. The principal reason for this is the course of earth movements already mentioned, whereby the older rocks have been worn away long since. The Cambrian dawned with a fully developed and highly organized life, which was probably developing since, or even before, water commenced to flow 1000 million years earlier. By Cambrian times the animal kingdom had developed up to the Crustacea, and the vegetable to highly organized algae. From that date earth history shows a reasonably complete record, although details of geography cannot be confidently traced until we reached the Tertiary period. Some of the more important dates in the earth's history are given in the following table:—

Age of the Sun: 8,000,000,000,000 years		
Age of the Earth: 3,000,000,000 years		
Probable Future Life of Earth: 7,500,000,000,000 years		
Consolidation of Planet—Period of Density—Stratification—Cooling—Crinkling, &c.: 3,000,000,000 to 1,600,000,000 years		
Commencement of Erosion and Deposition of Earliest Sedimentary Rocks: 1,600,000,000 years		
Age of Oldest Rocks now remaining—Geological History begins: 640,000,000 years		
CAMBRIAN	600,000,000	Life well developed
DEVONIAN	390,000,000	Vertebrate animals and land plants first appeared
PERMIAN	220,000,000	Existing plant phyla and animal phyla up to Reptiles are represented
CRETACEOUS	100,000,000	Mammals well established
TERTIARY	100,000,000 to 1,000,000	Primates first appeared
PLEISTOCENE	1,000,000 to present day	Man first appeared
Pre-Glacial *Günz* *Riss-Würm* *Würm*	1,000,000 800,000 250,000 100,000 40,000	Pithecanthropus Negrito Neolithic Aryan Bronze Age (Azilian)

The succession of events as disclosed by this history is as follows: After a very long period, marked by a fairly uniform grouping of forms of life, erosion produces a flat, level world, with deep accumulations of sediments in long troughs off the edge of the continents. The general temperature gradually rises under the influence of radio-active properties in the earth's crust, and this is accompanied by a degree of fusion of the substrata allowing the surface to adjust with great delicacy. Coal measures, often thousands of feet thick, show an adjustment to water-level so perfect that the addition of one-eighth of an inch of sand depresses the level by a corresponding amount. This phase is accompanied by a very equitable climate, and becomes a *coal age.* In time, the pressure of accumulating sediments squeezes out molten rock to the surface, and we have a major *volcanic period*, such as covered the Deccan 600,000 square miles with lava 1000 feet thick, and Southern Australia from Mount Gambier in South Australia to Melbourne and North-East Tasmania with basaltic lava in places hundreds of feet in thickness. This is accompanied by a period of great mountain foldings. These two results release the accumulated pressures and internal heat, and are followed by an *ice age.* Then the world settles down to a long period of quiescence—30 million years or so—until erosion again upsets the balance. The forms of life develop slowly during the quiescent period, primarily under the influence of normal biological controls, but each revolution marks a change in environment, which is always accompanied by the extermination of many forms, the rise of some newer and more highly developed forms, and a regrouping of life generally. The ancestral forms of each phylum have probably been in existence since Pre-Cambrian times, but each revolution gives an impetus to some previously repressed form, and spurs on development to an extent not seen with any other influence.

There have been, in all, some 20 revolutions of varying intensity, of which some four or six were of outstanding intensity. These are usually known as: (1) The Charian, which initiated the Cambrian period; (2) the Caledonian, which terminated the Silurian and initiated the Devonian; (3) the Hercynian, which terminated the Permian period—the end of the Palaeozoic era—and initiated the Mesozoic era; and (4) the Alpine, which commenced in the early Tertiary, and which is only just terminating. It is impossible here to describe the effects of these revolutions, and I must be content to remark that each produced very definite land masses and mountain ranges, traced in many parts of the world, and which were reflected in Tasmania.

We may therefore truly describe the world as pulsating. History shows a definite rhythm, and this rhythm is part of the very nature of the earth. Moreover, it has supplied the motif for the development of all land features and all forms of plant and animal life. Indeed, it is not too much to say that life itself is but one manifestation of this pulsating, rhythmic attribute of the earth—the mother of all life.

MAN

And so, finally, we come to MAN. It is out of the question for me to discuss here the origin of the genus of *Homo*, but we can see the results of the world's pulsations nowhere better than in the story of the human race. When the early ancestors of the primates were hunting across the Eurasian plains with their shaggy coats and long tails, there were no Alps or Himalayas, no Mediterranean, no Bass Strait. The Tertiary period has witnessed the development of our present geography. The preceding era had been the age of the giant reptiles. With the beginnings of the Tertiary we see the rise to prominence of the insects and their associates—the flowering plants and grasses. At first, plant and animal forms spread indiscriminately through the world—eucalyptus trees and marsupials in Europe and America, oaks, elms, willows, &c., in Australia. At this time land was emerging from the great sea, Thetys. Ancient Malaya connected Southern India with Australia, Central Australia and the Ganges valley were under the ocean, and Tasmania was connected to South America *via* the Antarctic. Then followed a great outpouring of volcanic lava over a considerable portion of the earth's surface. The Alpine-Himalayan chain was gradually folded over the remnants of the Hercynian mountains, and the Pacific squeezed its margins outwards over America, Asia, and Australia. Finally, the world passed into the last ice age—from which we are now only just emerging.

The world is divided into certain geographical zones, as shown in Fig. 4. Man originated in the equatorial forest belt (from North Africa to Malaya), before the Alpine-Himalayan chain had been raised sufficiently to form an impassable barrier, and here the forbears of our race lived for perhaps 10 million years, until the pulsations of the globe which gave them birth shook them from their leisured existence. The gradually rising mountain barriers very early segregated branches of the human family, and, probably, from originally black-skinned ancestors the more progressive races developed from stocks trapped north of the mountains. Then the ice age came on. This had a very marked bearing on the distribution of these geographical zones. Segregation into such zones does not appear to be usual in earth history, but is a definite accompaniment of an ice age, and the polar ice sheets control the distribution of each zone. As the ice advances from the poles each zone presses nearer the equator and contracts the equatorial forest belt, and as the ice retreats the other zones follow it towards the poles, allowing the equatorial forest belt to expand. There were four separate ice invasions during the last ice age. Four times the ice has advanced and receded. On each occasion it reached to about the latitude of southern England, central Germany, and Russia, and the Canadian-U.S.A. border.

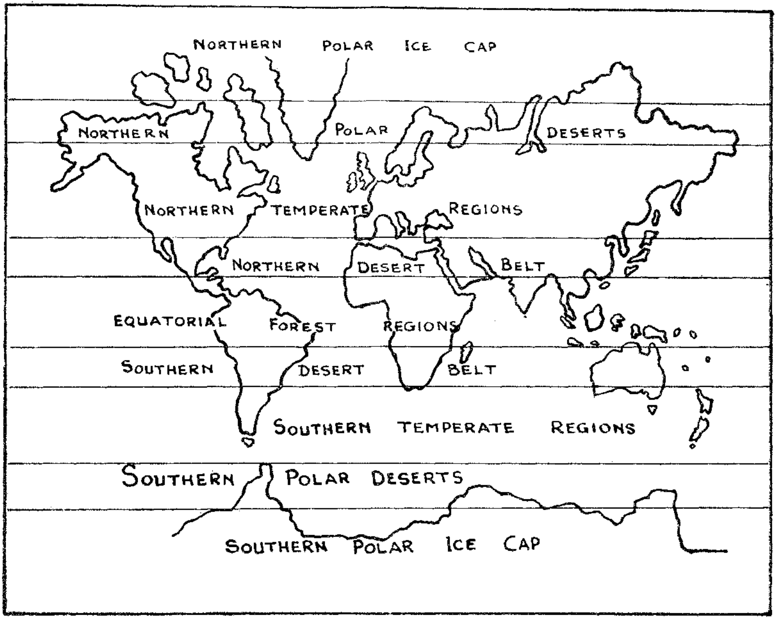

Fig. 4.—The Major Geographical Zones of the Surface of the World.

Prior to the first onset, man's ancestors had spread widely through the tropical forests. It took a large area to support a small number of these primitive tribes. Apes and monkeys were well developed, and also *Pithecantropus* and his contemporaries. Then the ice came down and pushed the desert belt southward, contracting the forests, and, with them, man's food areas. In time, the ice receded, but the consequence of the intense struggle for existence caused by this restriction was a new race of mankind—higher in every way. This happened three times more, until the modern races grew from the intense struggles of nature's testing—aided in some cases by climate and by the fact that some races were trapped between mountains and deserts to the south and the cold temperature regions to the north. These influences also directed and controlled migrations until the greater portion of the world was populated. In places, earth movements and long extensions of the oceans along newly forming troughs cut off and protected remnants of earlier races. In other parts the struggle for existence, nature's uplifting influence, continued, for some fortunate groups, the work initiated by ice.

Another and very important factor also resulted from the ice age. As a great deal of water was stored up as ice, the level of the sea sank. This occurred to a depth of 150 feet all over the world at the time of maximum intensity. During that time rivers and streams were enabled to cut below present sea-level, and coral reefs could grow at a depth at which coral cannot live to-day. As the ice melted the sea level arose and dammed back the newly cut valleys. During the interglacial phases the sea level actually rose higher than we see it to-day, as we are not yet entirely out of the last, or fourth, glacial phase. This caused the streams to deposit terraces in their newly eroded valleys. During later ice phases these terraces were largely eroded again. So we can see to-day over much of the world, including Tasmania, a definite series of three or four terraces at the mouths of rivers. Now, primitive races of mankind lived along the courses of these rivers, and left their bones and their tools in the river mud and gravel. The anatomist can trace the development of the races in the bone remains, and the association of stone implements with these bones enables us to classify human culture in historical sequence. The geographical sequence of the terraces is easy to work out, and in this way human history has been correlated with the earth pulsations which both produced the terraces and induced the development of successive races. To this scale has been added another. In regions on the border of an ice cap, in winter time, the water is frozen and stationary. Summer melts much ice, and the water carries away a great quantity of material worn by the ice from its bed. This is deposited as a fairly thick layer. The succeeding winter makes a break, when only a very thin layer or none at all is deposited. Thus is built up a rock known as *varved shales*, in which the record of passing years is accurately preserved. These alternating seasonal layers have been counted in many places, and an absolutely correct time scale is thus provided.

The story of the human race has been laboriously built up from all those various factors, and we can now place the origin of different peoples in their correct relationship relatively to each other. We can connect human occupation of a given locality with the river terrace in the process of formation at the time of that occupation, and we can correlate these terraces by means of the known phases of the ice invasions, with corresponding terraces anywhere in the world. The combined result gives us an accurate history of man's occupancy of the earth and an accurate geography of any given locality at any particular stage of the human period. (See for Tasmania the diagrams given in my paper published in this journal for 1934. The succession there given corresponds very closely with that in England.)

Earth Movements in Tasmania

Tasmania occupies a very important and definite position in geography as a wedge of the Australian continental mass projecting into the oceanic masses to the east and west. These masses have been in approximately the same relative position since the beginning of geological time, and Tasmania has been, as it were, a buffer. Thus, it has been subjected to continued stresses—at one time of compression, at another of torsion—with a result that it has never been stable, and, whereas on the mainland it is possible to go from Broken Hill to Broome—nearly 3000 miles—without a major change of rock, Tasmania has representatives of almost every geological period and has felt the effects of every earth movement. (Fig. 5.)

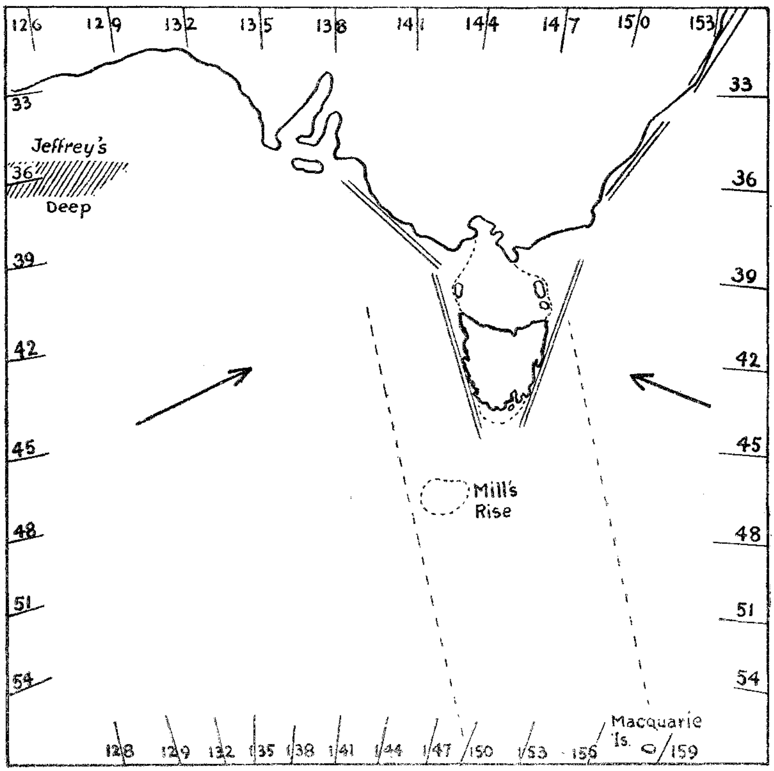

Fig. 5.—The Major Continental Trend Lines in the Neighbourhood of the Tasmanian Peninsula.

Tasmania is the southern terminal of the Eastern Australian Continent. Bass Strait is merely a flooded portion of this peninsula. The diagram illustrates the position of Tasmania as a wedge between two converging pressures. The submarine ridge of which Mill's Rise and Macquarie Island are portions has not yet been satisfactorily explained, but is clearly associated with the general structure of the Eastern Australian Continent.

We have only time to deal with the most recent. A revolution which closed the Silurian, and which may be roughly correlated with the Caledonian of Europe, left a cordillera of mountains over the present position of Tasmania, folded over older land to the west and enclosing great batholiths of granite. This would be

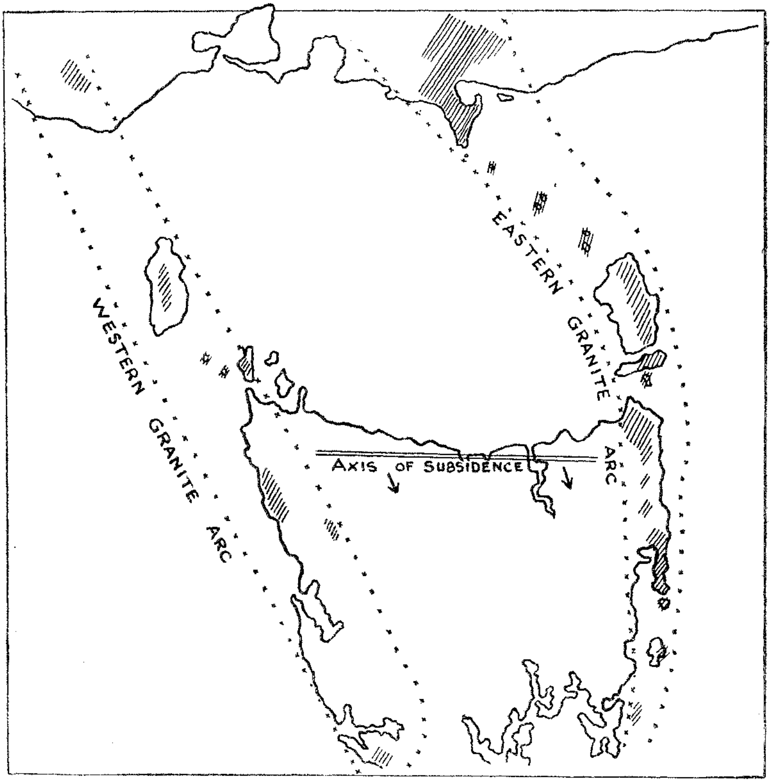

Fig. 6.—The Two Granite Arcs.

These form the skeleton of Tasmanian physiographic structure. The actual centre of the axis of subsidence during Permian times may have been further north, under the now flooded Bass Strait, but the position shown on the diagram is the apparent axis as far as data at present available indicate. Granite outcrops are shaded. Many facts indicate considerable subterranean masses within the dotted lines indicating each arc.

some 420 million years ago. Before Carboniferous times these mountains had been eroded to a plain, exposing the granite cores. One hundred and sixty million years are represented in this phase. Then followed a general and very slow subsidence to the southward about an axis roughly across Northern Tasmania. (Fig. 6.) In the trough thus formed, which was probably only the northern extension of a greater block extending perhaps to Antarctica, sediments typical of shallow seas, sand dunes, and swamps, accumulated to a depth of perhaps 8000 feet. This phase extended until the Triassic or Jurassic periods, some 60 million years. Then the geosyncline thus formed foundered in an upwelling magma of basaltic *Sima*, which intruded on the sediments, and gave us our dolerite rocks. These sequences are also to be found on the coast of Antarctica opposite Tasmania, indicating that Tasmania and Adelie Land were the edges of a vast foundering land mass. The doleritic intrusions may be roughly correlated with the Hercynian revolution of Europe, but somewhat later in point of time.

We can form little idea of the geography of Tasmania at this time, but it was very broken, with perhaps mountain ranges. A long interval of quiescence followed—some 100 million years—during which the land was worn to a level plain. Then Tasmania felt the effects of the earth revolution which also produced the Alpine-Himalayan and Rocky-Andean mountain chains. At this time, and very likely at other earlier times, Tasmania extended far to the east and west of its present coasts, and was part of an inland continental mass. The Alpine revolution was not felt as severely as in Europe or New Zealand, but more so than in Australia. As a result of pressure from east and west, Tasmania was broken and uplifted in jagged blocks, and at the same time there were large subsidences off the coasts. The first of the uplifts raised the western area and the north-east corner, and sufficient time elapsed to erode the overlying sediments and dolerite sills from these parts. This uplift must have been in the vicinity of 8000 feet, and was most pronounced. Then came a fairly general uplift over all Southern and Eastern Tasmania, excluding the north coast and the midlands. The extent of this was about 1500 feet. Subsequently disjointed blocks were raised to a further 3000 feet, and now appear as our mountains. There were several such movements, and blocks were raised differentially. Accompanying these uplifts, considerable subsidence off the west and the north-east coasts occurred, and, later, a large area off the southern coast of Tasmania, including Storm Bay, foundered along very regular breaks. This, in its turn, had a marked effect on the valley erosion in the south, rejuvenating the rivers and giving a marked trough in the old valleys. The original sides of the pre-submergence valleys can be plainly seen on the platform at 500-400 feet along the Derwent Valley and hills of Southern Tasmania.

These movements extended into the ice age. We can follow the four ice ages in Tasmania, although the first is obscure. These provide an excellent correlating time-scale, particularly as the latest elevation occurred subsequently to the two earlier ice phases. It is apparent that very dry conditions prevailed in Tasmania during some of the interglacial phases, and during the ice phases many rivers in the unaffected coastal portions were much more considerable than at the present time. River terraces all along our coasts correspond very closely with similar features in Europe.

During each ice age the streams cut below present sea-level, and during each interglacial phase the sea-level rose and banked back the streams so that they deposited terraces in the valleys previously excavated. These terraces can be correlated with the various ice ages. So can the movements of the desert belts. Therefore, when the remains left by a particular human race are found in or on a particular terrace you can say that they appeared in that locality at a given time. These successive factors have been worked out for the Thames valley, and now research shows that a corresponding time-scale is available for Tasmania. The Derwent, Coal, Huon, and Tamar valleys show series of terraces that correspond remarkably accurately with those of Europe. The Derwent and other rivers have cut 150 feet below present sea level, and have piled up terraces to an elevation of 100 feet above sea level (Lewis, 1935). These over-deepenings and terraces correspond to the rise and fall of the sea level during the ice age. During these rises and fallings, so accurately marked by river cuttings and terrace buildings, and, in higher altitudes, by the effect of ice, man arrived in Tasmania. The date can be accurately fixed as during the Yolande-Margaret interglacial, as his artifacts appear suddenly on these terraces. That corresponds to the Riss-Würm, interglacial of the northern hemisphere, and may be dated as 150,000 years ago.

A considerable controversy has arisen lately as to how the Tasmanian aborigines arrived here. Until the last year or so, Sir Edgeworth David's dictum that they arrived across a dry Bassian land bridge was accepted. Professor David showed that the maximum phase of the Mindel (Malanna) glaciation the sea was 150 feet lower than it is to-day. That this was so is demonstrated by the Derwent trough. This would have been sufficient to have given a double land bridge across Bass Strait. Unfortunately for this convenient theory. recent work shows that the aborigines did not arrive until much later. During Mindel times—some 600,000 years ago—the Negrito race, of which the Tasmanians were a branch, were developing in Northern India, and had not spread further. They did not reach Southern Australia until much later. The subsequent ice ages were not sufficiently intense to lower the sea level to a depth which would make a land connexion between Tasmania and Victoria. Investigation of the coast of Bass Strait indicates that the coast-line, at any rate, has not sunk in post-Yolande times.

Why did the aborigines cross to Tasmania? The answer is clear. Throughout the period from their first migration into Australia, the central desert belt, in response to the pull of the ice-sheet, was moving up and down across the continent. At the time they first appeared in Tasmania the southern portion of Australia was in the grip of the desert. To such an extent was this so that the Buffalo ranges in Victoria at 5000 feet show no signs of permanent snow, while ice descended to sea level on the west coast of Tasmania only 400 miles further south.

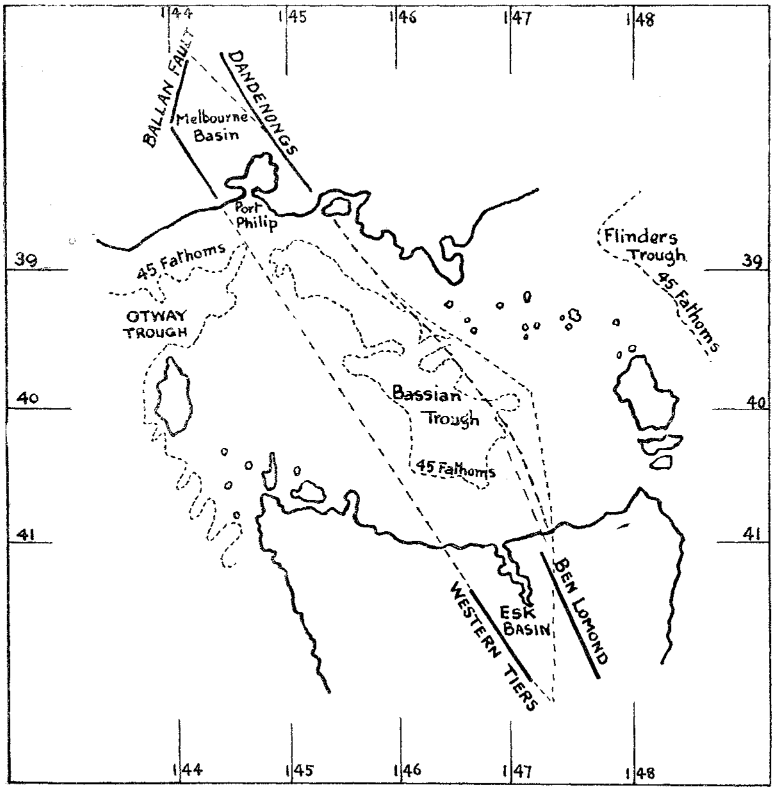

Fig. 7.—The Bassian Trough.

The diagram illustrates the general trend lines of the geography of Bass Strait. It also illustrates the vital connexion between geographical data to be gathered on both sides of the strait. The neglect of this correlation has led to many of the doubts which now exist as to the geography of South-eastern Australia.

An examination of Bass Strait is instructive. Although the Tasmanian coast shows terraces dating back to at least Yolande times, soundings disclose a peculiar trough 270 feet below sea level. This is a lenticular extension of the plains that run from Tunbridge to the coast in Tasmania, and from Bacchus Marsh to Port

Phillip in Victoria, and it connects these plains. The Bassian trough cannot be waterworn, and as there is no outlet, if it had not been flooded, it would have been an inland sea or salt lake. It can only be due to earth movements. The subsidence south of Tasmania is of very recent date, so much so that at least two river valleys flowing from the ocean northwards are observable—one at Port Davey and one at Cockle Creek. The Flinders and Otway troughs and the subsidence to the south indicate a squeezing movement, and point to the origin of this submerged inland sea. When did all this happen? The very shape and nature of the Bassian trough point to a possible counterpart—the Dead Sea and Jordan Valley.

Palestine as a Key to Tasmanian Physiography

Palestine presents a remarkable key to some of the problems of more recent Tasmanian physiography. The plateaux of Judea and Moab were uplifted at approximately the same time as our Central Plateau, and to the same height. The earth movements that produced both sets of features were due to the same agency, and were exactly similar in origin and effect, and the boundary fractures as described for Palestine might be the faults which are causing us so many difficulties in interpretation here. Pictures of the Judean Mountains from the Philistine Plain, and of the Western Tiers from the South Esk Valley, illustrate the similarity better than any words can do. But beyond these features, there are two others: (1) The flooded area of the Mediterranean, and (2) the rift valley of Dead Sea. From Galilee to Akaba there extends a break in the plateau which, at one place, drops to 600 feet below the sea level. This is an area which has played the most important part in the history of mankind, and there has been preserved for us an actual historical record of happenings here during the life of human beings. We now have brought our story of the world down to the time of the Book of Genesis. Two early legends are there preserved from a time far more ancient than the time when they were reduced to writing. The first is the story of the Flood, and the second is the story of Lot.

The Flood was an actual happening, established beyond doubt by the wide distribution of legends through the earliest writings of mankind. It was presumed, until recently, that it was the result of the rising of the sea level after the last (Würm or Margaret) ice phase. It could not have been this, as the rise was insignificant. The rise after the Mindel ice sheet had waned would have been sufficient, but at that time—600,000 years ago—the human race was too primitive to make records. The evidence all points to the fact that the Flood was the result of the submergence of the Mediterranean-Euxine-Caspian-Aral basin, as the last phase of the earth movements associated with the Alpine revolution. The land then submerged was the happy hunting ground of the Iberian peoples, sometimes known as the Dark Whites, represented in history by the Iberians of Spain, the Trojans, the Philistines with their great cities Tyre and Carthage, the Helots of Greece, and some of the tribes of Italy. These people were 'wicked' (that is, foreigners) to the writers of the Old Testament. To them the Flood was the outstanding event in history and the source of many legends. At about the same time, and as the result of similar earth movements, the transverse fissure of the Jordan valley subsided, and we read the account, written at a much later date, of this happening in the story of Lot. The Cities of the Plain are traditionallly situated in the Dead Sea basin, and Genesis specifically mentions Lot as escaping to Moab, an unlikely course if these cities had been situate in the Philistine Plain. No other localities fit. Genesis states that Sodom and Gomorrah were overwhelmed with fire and brimstone. No volcanic activity appears to have occurred in these regions, but earthquake movements were highly probable, and considerable landslides from the 4000-foot cliffs surrounding the rift valley were also possible. The date of these happenings may be fixed at late Azilian times—about 40,000 B.C.—and they are confirmed by ethnological, geological, and geographical evidence.

Some such minor earth adjustment is apparent across Bass Strait and to the south of Tasmania, and the similarity is too close to be ignored, although, getting so close to the present day, actual contemporaneity to a few thousand years cannot be pressed in the present state of our knowledge. Nevertheless this fact is undoubted. We see certain results of earth movements in Tasmania, and portion of the human race has left some legendary records of very similar happenings elsewhere. In the absence of reasonable text-books of Tasmanian geography we must turn to the legends of Genesis for assistance.

In the present imperfect state of our knowledge I am not prepared to say that Bass Strait was submerged after the coming of the Tasmanian aborigines. The evidence of the coastal terraces points in the other direction, but Bass Strait is an earthquake zone at the present time, and the great trough was probably the result of a continual pressure or subsidence after the formation of the terraces and the passage of the aborigines. This, however, does not affect the general similarity of the earth movements.

I give below a list of works which should be consulted by students who are interested in the subject of this lecture. The list is arranged in the order recommended for study.

REFERENCES

1. HOLMES, ARTHUR.—*The Age of the Earth.* (Benn's Sixpenny Library.)

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5. WRIGHT, W. B.—*The Quaternary Ice Age.*