# *EARTH MOVEMENTS IN AUSTRALIA*

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Does Australia move? As an answer to this question we wish to know whether Australia has movements which are particularly its own. That it shares in the general movements of translation and rotation of the planetary body, of which it is a part, is a fact with which we are acquainted. Are the mountains of our continent sometimes higher and sometimes lower relatively to sea level than they are at the present moment?

Is the ground on which the reader of these notes now stands actually at rest, or is it in a state of vibration?

Do the vast plains constituting the interior of this country slowly rise and fall as if pulsating to the breathing of some mighty animal buried deep beneath the surface?

George Darwin calculated how far a continent like Australia is depressed when there is an increase in barometrical pressure. The effect of increasing the atmospheric pressure over an area like Australia, to borrow an illustration from Sir William Thomson, may be likened to placing a pile of sovereigns on the surface of a block of jelly. Darwin assumed that the area which was to be distorted, had a rigidity at least equal to that of steel. The result of the calculation was alarming, and indicated that if our continent had been less rigid, a little flatter, or if the fluctuations in atmospheric pressure were abnormally great, much of our country might possibly be depressed until it disappeared beneath sea level.

That atmospheric pressure, the loads due to tidal movements on the coast, lunar attraction, the piling up of snow and ice upon the mountains and in the Polar regions, and other causes, may one and all produce distortions and changes in level – are phenomena which have a possible existence, and the demonstration of their actuality leads to investigations of more than ordinary interest.

For those who have to make astronomical observations and refined physical measurements, a knowledge of these movements is of the greatest practical importance. Very many of the observations with which astronomers and physicists have to deal are made on the assumption that the ground on which we stand is actually at rest – an assumption which we are gradually coming to regard as not absolutely true.

Sometimes it appears that the ground is in a violent state of tremulous motion, while at other times phenomena are presented to us which appear to indicate that the ground is being slowly tilted. If this latter class of movement has a real existence, we may imagine that, although the walls which line our streets have been built truly plumb, by the tip which takes place in the soil they may at times be overhanging, first in one direction and then in another. That movements of this order are not altogether a product of the imagination, we may refer to the interesting observations recently made by Mr Russel, of the Sydney Observatory, on the changes in the level of the waters of Lake George. As in other lakes it is found that the waters of this lake rise and fall, and subsequently oscillate with changes of the barometer and wind. In addition to these movements there are others which are apparently only explicable on the assumption that the bed of the lake is slowly tilted. These disturbances are similar to the strange changes in level, which sometimes take place in the lakes of Switzerland and other countries which are known as Seiches or Rhussen. About movements of this kind which have also been indicated by the change in the position of the bubbles of delicate levels, and other strange phenomena, but little is at present known. We may call them earth pulsations.

That tremulous motions, or microseismical disturbances, as they are technically termed, have an existence in Australia will be clear to anyone

who visits the Melbourne Observatory, where he may examine a contrivance designed to eat them up. This contrivance is an arrangement of india-rubber bands, employed to support a basin of mercury, in which reflection observations are made beneath the transit instrument. When the basin rested on the ground, the surface of the mercury was at times so much disturbed that observers were detained while endeavouring to obtain a steady image. To obviate this, Mr Ellery, the director of the observatory, supported the basin by the abovementioned bands, the effect of which has been to absorb the minute motions coming from the ground, and thus prevent them from reaching the basin.

Many years ago, Sir George Airy fought against a similar enemy at Greenwich. After tabulating the nights on which it had been almost impossible to obtain observations, it was found that many of these agreed with public holidays, and especially with those days on which crowds of sightseers came to Greenwich park, many of whom would indulge in the amusement of rolling down the hill on which the observatory was situated. A curious point connected with these artificially-produced tremors was that they continued for many hours after dark, at which time we will assume that the amusement of rolling down the hill had terminated. Sir George triumphed over the intruders by the method more recently employed by Mr Ellery, namely, by employing flacid springs to eat them up. Another observer, Captain Kater, whose name is so well known in connexion with pendulum observations, was not so successful as Sir George Airy and Mr. Allery. After struggling with the enemy, he was vanquished, and compelled to fly from London traffic and seek more stable ground in the country,

Lieutenant-colonel Palmer, when engaged in making observations on the transit of Venus in New Zealand, discovered that he could fortify his instruments against the tremors produced by passing trains by digging trenches between himself and the source of the annoyance. Before the Naval Observatory was established at Washington, Professor H. M. Paul was detailed off to test the city and its suburbs, in search of stable ground. The account which he has published in the "Transactions of the Seismological Society of Japan", about this tremor survey, is a valuable addition to our knowledge of these microseismical phenomena. In some places the passage of a train would be announced as a storm of tremors at distances of more than a mile. Might we not here ask whether it is not possible to produce and use earth tremors as a means of communication? We can telegraph through the atmosphere without a wire. It is proposed to telegraph across an ocean without a cable. Why can we not telegraph through the earth? If we can only produce and use earth tremors as a means of communication between distant points, our enemies will become our friends. The stories of the fights which scientists have waged against these microscopic enemies of stability form one of the most interesting and instructive chapters in the history of observational science.

From what has now been said, it will be seen that earth tremors are of two kinds – artificial and natural. The artificial tremors are produced every time a waggon rolls along a street. The manner in which the natural tremors are produced is unknown. They suddenly appear in districts especially when the barometer is falling. Like a storm, they rage for several hours, after which they disappear as mysteriously as they came. Some argue that they are merely surface phenomena, while others attribute them to ebullitions and other disturbances deep beneath the surface of the ground, intensified by the relief of atmospheric pressure up above. That they are directly connected with barometrical fluctuations must make them an object of great interest to the colliery proprietor, who has to deal with mines giving off explosive gas. It is known that the gas in many mines increases with a fall in the barometer, and if the barometer was not so sluggish in its movements, it would be a good indicator of approaching danger. Unfortunately, it often happens that a mine has become dangerous some hours before the barometer has shown any

decided change. All who have studied coal mining know the inestimable boon it would be if the coal miner had the means of forewarning himself against the danger of escaping gas. For this end many instruments have been invented, but hitherto none of them have given satisfactory results. Earth tremors and barometrical changes have a relationship. Barometrical changes and the escape of gas are likewise closely connected. Why, therefore, should we not seek for a relationship between earth tremors and the escape of fire-damp. I trust that this suggestion may come to the notice of some of the colliery proprietors in Australia. That there is some kind of relationship between these phenomena is tolerably certain, and when we reflect on the enormous interests at stake at almost every coal-mine, it seems imperative that everything should be done to obtain a knowledge of this relationship.

At this point many may ask how we are able to assure ourselves that these minute movements have a real existence. The reply is as follows :- Take a weight and suspend it from a rigid iron stand by a thin brass wire. Enclose this pendulum in a tube, so that it is not disturbed by currents of air. Now, with a microscope, look through the glass at a needle-like pointer fixed on the pendulum. Two things which may easily be recorded are, first, that the pendulum is seldom if every at rest, and second, that its movements increase with a fall in the barometer. Father Faura, of Manilla, tells me that an instrument of this sort is almost as good to him as a barometer. The foundations on which an instrument of this description rests must necessarily be as solid as possible, and at the same time far removed from all causes tending to produce artificial tremors.

Now for a few words about the more violent movements which we call earthquakes. Since April 1883, hundreds of these disturbances have shaken the eastern portions of Tasmania. Many of these movements have made themselves felt in Victoria, whilst one or two have been propagated even as far as New South Wales. General accounts of these phenomena, accompanied with many details, have already been published by Commander Shortt, R.N., Mr. A.B. Briggs, and Mr G.S. Griffiths. The first named gentleman possesses a very complete list of these disturbances, which, so far as it has gone, shows that they commenced gently, gradually became more and more numerous, until at last their frequency reached a maximum. From this time they have been on the wane, both as to their numbers and their intensity. It is to be hoped that this list may shortly be published. In itself it tells us of the birth, the vigorous manhood, and the decline of a seismic area, and it would undoubtedly form a valuable addition to seismological chronology.

From the various investigations which have been made, it appears that there is a line of weakness in the earth's crust running parallel to the eastern coast of Tasmania. From time to time, whilst sinking to a state of equilibrium, this line gives way, first at one point and then at another. Each of these movements is announced as a series of tremors which now and then may be accompanied by one or more violent lurches. If this is a correct view to take, then in a few years it is possible that actual stability may be reached, and the earthquakes of Tasmania and Victoria become tradition of the past.

A second view is that the disturbances are directly connected with the capillary intrusion of seawater to volcanic foci, consequent on which there are explosions and ruptures along the abovementioned line of weakness. Be it as it may, it is certainly remarkable that the greater number of earthquakes in the world occur in volcanic countries, but not actually at volcanoes. They usually originate on or near the foot of a slope beneath deep water. Eighty per cent of the earthquakes in Japan have such an origin. The great earthquakes of South America, which are sometimes propagated to the shores of this colony as a series of sea waves, originate beneath the deep water off the western coast of that continent. Many of the earthquakes of New Zealand have originated beneath the ocean at the entrance to Cook's Straits.

Lastly, we have the earthquakes which have so recently been felt in Melbourne probably originating, as pointed out by Commander Shortt, near to the edge of the 2,000 fathom line off the north-east shore of Tasmania. In connexion with these remarks, it must be remembered that although Southern Australia cannot now be included in the list of volcanic countries, in extremely recent geological times the intensity of volcanic activity in this portion of the world must have been very great. Relics of this activity are to be seen in the cones and craters of Colac and other places, the enormous flows of basaltic lava and in the hot springs of the interior.

To enter fully into the many theories which have been adduced to account for earthquakes would here be out of place. Earthquakes are due to a complexity of causes, and it is only to two of these that we have here made reference. When we have taken diagrams of the disturbances which now and then alarm us, and have compared these with the diagrams obtained from disturbances produced by known causes, we shall be able to speak more definitely of the causes which produce the Tasmanian and Victorian shakings.

The last movements which are left for our consideration are the secular elevations and depressions. Evidence of such movements are in existence in Victoria and Tasmania. These phenomena have always formed a theme for the geologist, and without them the science he has created would practically be without existence. They differ from all the other movements of which we have spoken by the greatness in their amplitude, and in the length of their period. By these movements ocean bottoms have gradually become hills, and coast lines have been submerged.

I have now spoken of four classes of movements, all of which have an existence in this portion of Australia. First, there are the slow pulsatory movements, which are unnoticed on account of their extreme slowness. The time occupied for arise and fall may be from 15 minutes to an hour. Next we have the tremors. These are unnoticed, on account of their minuteness. From time to time they vary in their intensity, and it is probable that there is no district where they could not be studied. Thirdly, there are the sudden and violent movements called earthquakes; and lastly, we have the slow oscillations which some day may convert Bass's Straits into dry land.

All these movements appear to be intimately related to each other. Professor Rossi, of Rome, thinks that by watching the progress of a microseismic storm, he can foretell the occurrence of an earthquake. The tromometer, or tremor measurer, as an indicator of movements going on in the interior of the earth, is expected by some seismologists to become what the barometer is as an indicator of the movements in the atmosphere.

How far all these movements are related to other terrestrial phenomena, like earth currents, changes in magnetic intensity, is as yet unknown. Earth tremors probably hold a connexion with the escape of fire-damp and the circulation of underground waters. Nearly all the phenomena which have been mentioned offer new fields for investigation. In several countries this investigation has been commenced, but before it can be completed it will need co-operation in all quarters of the globe. In Victoria, as in other parts of the World, both time and money has been devoted to the study of the changes which take place in the atmosphere, to the movements of the ocean, and to the motion of the heavenly bodies. The only movements which we have not yet studied are those of the soil on which we live. These present us with phenomena the study of which will lead to results both utilitarian and scientific. In the endeavour to fathom and utilise the phenomena by which we are surrounded, it seems almost imperative that attention should be given to the changes taking place beneath our feet. Australia moves, it presents us with phenomena which in nearly all quarters of the globe have been neglected, and it remains for us to undertake their study.