Astronomy and Geology.

ANCIENT TIDES AND GEOLOGICAL PERIODS.*

I suppose the most-read book that has ever been written on geology is Sir Charles Lyell's "Principles." The feature which characterises Lyell's work is expressed in the title of the book, "Modern changes of the Earth and its Inhabitants considered as Illustrative of Geology." Lyell shows how the changes now going on in the earth have in course of time produced great effects. He points out triumphantly that there is no need of supposing mighty deluges and frightful earthquakes to account for the main facts of geology. There is, however, one great natural agent of which Lyell does not take adequate account. He does not attach enough importance to the tides. No doubt he admits that the tides do some geological work. He even thinks they can do a great deal of work. The sea batters the cliffs on the coasts, and wears them into sand and pebbles. The glaciers grind down the mountains, the rains and frosts wear the land into mud, and rivers carry that mud into the sea. In the calm depths of ocean this mud subsides to the bottom; it becomes consolidated into rocks; in the course of time these rocks again become raised, to form the dry land with which we are acquainted. The tides, says Lyell, help in this work. Tidal currents aid in carrying the mud out to sea; they aid to considerable extent in the actual work of degradation, and thus contribute their quota to the manufacture of stratified rocks. Such is the modest *rôle* which Lyell has assigned to the tides, and no doubt the majority of geologists have acquiesced in this doctrine. Nor can there be any doubt that this is a just view of tidal action at present. That it is a just view of tidal action in past times is what I now deny. Lyell did not know—Lyell could not have known—that our tides are but the feeble surviving ripples of mighty tides with which our oceans once pulsated. Introduce these mighty tides among our geological agents, and see how waves and storms, rivers and glaciers, will hide their diminished heads. I must attempt to illustrate this view of tidal importance in ancient geological times. Let me try by the aid of the tides to explain the great difficulty which every one must have felt in regard to Lyell's theory. I allude to the stupendous thickness of the Palæozoic rocks. Look back through the corridors of time in the manner in which they are presented to us in the successive epochs of geology. We pass rapidly over the brief career of pre-historic man; then through the long ages of Tertiary rocks, when the great mammals were developed; back again to the much earlier period when colossal reptiles and birds were the chief inhabitants of the earth; back again to those still earlier ages when the luxuriant forests flourished that have given birth to the coal-fields; back once more to the age of fishes; back finally to those earliest periods when the lowest forms of life began to dawn in the Palæozoic era. As we date remote ages astronomically by the distance of the moon, so we date remote ages geologically by the prevailing organic life. It is a great desideratum to harmonise these two chronological systems, and to find out, if possible, what lunar distance corresponds to each geological epoch. In the whole field of natural science there is no more noble problem. Take, for example, that earliest and most interesting epoch when life perhaps commenced on the earth, and when stratified rocks were deposited five or ten miles thick, which seem to have contained no living forms higher than the humble Eozoon, if even that were an organised being. Let us ask what the distance of the moon was at the time when those stupendous beds of sediment were deposited in the primæval ocean. We have in this comparison every element of uncertainty except one. The exception is, however, all important. We know that the moon must have been nearer to the earth than it is at present. There are many very weighty reasons for supposing that the moon must have been very much nearer than it is now. It is not at all unlikely that the moon may then have been situated at only a small fraction of its present distance. My argument is only modified, but not destroyed, whatever fraction we may take. We must take some estimate for the purpose of illustration. I have had considerable doubts what estimate to adopt. I am desirous of making my argument strong enough, but I do not want to make it seem exaggerated. At present the moon is 240,000 miles away; but there was a time when the moon was only one-sixth part of this, or say, 40,000 miles away. That time must have corresponded to some geological epoch. It may have been earlier than the time when the Eozoon lived. It is more likely to have been later. I want to point out that when the moon was only 40,000 miles away we had in it a geological engine of transcendent power. On the primitive oceans the moon raised tides as it does at present; but the 40,000-mile moon was a far more efficient tide-producer than our 240,000-mile moon. The nearer the moon the greater the tide. To express the relation accurately we say that the efficiency of the moon in producing tides varies inversely as the cube of its distance. Here, then, we have the means of calculating the tidal efficiency for any moon distance. The 40,000-mile moon being at a distance of only one-sixth of our present moon's distance, its tidal efficiency would be increased 6 x 6 x 6 fold. In other words, when our moon was only 40,000 miles away it was 216 times as good a tide-producer as it is at present. The height to which the tide rises and fall is so profoundly modified by the coasts and by the depth of the sea, that at present we find at different localities tides of only a few inches and tides of 60 or 70 feet. In ancient times there were no doubt also great varieties in the tidal heights, owing to local circumstances. To continue our calculation we must take some present tide. Let us discard the extremes just indicated and take a moderate tide of 3-feet rise and 3 feet fall as a type of our present tides. On this supposition, what is to be a typical example of a tide raised by the 40,000-mile moon? If the present tides be 3 feet, and if the early tides be 216 times their present amount, then it is plain that the ancient tides must have been 648 feet. There can be no doubt that in ancient times tides of this amount and even tides very much larger must have occurred. I ask the geologists to take account of these facts, and to consider the effect—a tidal rise and fall of 648 feet twice every day. Dwell for one moment on the sublime spectacle of a tide 648 feet high, and see what an agent it would be for the performance of geological work! We are now standing, I suppose, some 500 feet above the level of the sea. The sea is a good many miles from Birmingham, yet if the rise and fall at the coasts were 648 feet, Birmingham might be as great a seaport as Liverpool. Three-quarters tide would bring the sea into the streets of Birmingham. A high tide there would be about 150 feet of blue water over our heads. Every house would be covered, and the tops of a few chimneys would alone indicate the site of the town. In a few hours more the whole of this flood would have retreated. Not only would it leave England high and dry, but probably the Straits of Dover would be drained, and perhaps even Ireland would in a literal sense become a member of the United Kingdom. A few hours pass, and the whole of England is again inundated, but only again to be abandoned. These mighty tides are the gift which astronomers have now made to the working machinery of the geologist. They constitute an engine of terrific power to aid in the great work of geology. What would the puny efforts of water in other ways accomplish when compared with these majestic tides and the great currents they produce? In the great primæval tides will probably be found the explanation of what has long been a reproach to geology. The early palæozoic rocks form a stupendous mass of ocean-made beds which, according to Professor Williamson, are twenty miles thick up to the top of the silurian beds. It has long been a difficulty to conceive how such a gigantic quantity of material could have been ground up and deposited at the bottom of the sea. The geologists said, "The rivers and other agents of the present day will do it if you give them time enough." But unfortunately the mathematicians and the natural philosophers would not give them time enough, and they ordered the geologists to "hurry up their phenomena." The mathematicians had other reasons for believing that the earth could not have been so old as the geologists demanded. Now, however, the mathematicians have discovered the new and stupendous tidal grinding-engine. With this powerful aid the geologists can get through their work in a reasonable period of time, and the geologists and the mathematicians may be reconciled.—*Nature.*

*From a lecture delivered at the Midland Institute, Birmingham, by Professor Robert S. Ball, LLD., F.R.S.

To Clean Brass.—Rub the surface of the metal with rottonstone and sweet-oil, then rub off with a pieee of cotton flannel, and polish with soft leather. A solution of oxalic acid rubbed over tarnished brass soon removes the tarnish, rendering the metal bright. The acid must be washed off with water, and the brass rubbed with whiting and soft leather. A mixture of muriatic acid and alum dissolved in water imparts a golden colour to brass articles that are steeped in it for a few seconds.