rate of 1 foot in 3,000 years. He finally concludes that the time required to produce this thickness of rock, at the present rate of denudation and deposition, is only 28 million years.

That there is a considerable amount of confusion of ideas pervading this estimate, I think is pretty plain; but let us try and see by reversing his calculation in what conclusions we are landed.

It is evident, if the figures mean anything at all, that 3 millions of square miles 177,200 feet thick represent the whole of the rock removed by denudation in all forms since the geological history of the Earth began. Spread this over 57 million square miles of land, and we get a deposit 9,326 feet thick, deposited in all geological time. But we must not lose sight of the fact that these hypothetic sediments represent rocks made and destroyed over and over again, how often it would be difficult to determine; but taking the proportion of igneous rocks exposed on the surface at $\frac{2}{5}$ of the total area of land,[1] we may safely put it down as at least 12 times; that is, each particle of rock on the average has been denuded and laid down at least 12 times. From this it follows that the *actual* thickness of the sedimentary crust of the earth, if there were no sedimentary rocks except on site of the present land areas, would be $\frac{1}{5}\frac{2}{12} = 777$ feet. But even Mr. Wallace has to provide for fluctuations of his continents in some degree, and I believe he will admit that a considerable additional area has been alternately land and sea. If he will reason it out, mark its boundaries and estimate its area, I think he will find it cannot even on his own hypothesis be less than double the present land surface of the globe. The average thickness over this increased area would therefore be but 388 feet. If Mr. Wallace can prove that the average thickness of the sedimentary crust of the globe is no more than this, we shall be a long way on the road towards accepting both his hypothesis and his ideas of the Earth's age.[2]

It so happens that I have but just read "Island Life," and I find my views on the subject of Oceans and Continents characterized as "hasty and superficial." Perhaps they are, and if Mr. Wallace will but just put me right in my analysis of his own calculation, I may be rapidly converted to profounder geological ideas.

NOTICES OF MEMOIRS.

I.—The Decay of Rocks Geologically Considered. By T. Sterry Hunt, LL.D., F.R.S.[3]

THE author, in this paper, presented in a connected form the principal facts in the history of the decay both of crystalline silicated rocks, and of limestones or carbonated rocks, by atmo-

[1] See Chemical Denudation in Relation to Geological Times, p. 57.

[2] Dana, who, it seems (see Continents always Continents, "Nature," March, 1881, p. 410), preceded Mr. Wallace in many of the views expressed in "Island Life," estimates the average thickness of the sedimentary rocks in continental areas at 5 miles = 26,400 feet.

[3] Abstract of a paper read by T. Sterry Hunt, LL.D., F.R.S., before the National Academy of Science, at its meeting in Washington, April 17, 1883.

spheric agencies. Having first discussed the chemistry of the process, he noticed the production of spheroidal masses, or so-called boulders of decomposition, by the decay and exfoliation of massive rocks. He then proceeded to show that the process of decay is not, as some have supposed, a rapid or a local one, dependent on modern conditions of climate, but that, on the contrary, it is universal, and of great antiquity, going back into very early geological periods. These conclusions were supported by details of many observations among Palæozoic stratified and eruptive rocks in the St. Lawrence valley, as well as among Eozoic rocks in the Atlantic belt, as seen in Hoosac Mountain, in the South Mountain, and in the Blue Ridge. In connection with the latter he described the decay, not only of the crystalline strata, but of their enclosed masses of pyritous ores, and the attendant phenomena. The decay of the primal and auroral strata of the Appalachian valley, and the formation therein of clays and of iron and manganese oxides, was also discussed. The pre-Cambrian antiquity of the process of decay in the Eozoic rocks of the Mississippi valley, as shown by Pumpelly and by Irving, as well as similar evidence from Europe, was noted, while the more recent decomposition seen in the auriferous gravels of California was described and explained.

The final removal of the covering of decayed rock from many northern regions during the drift period was then considered; and the thesis advanced by the speaker in 1873, that the decay of rocks "is an indispensable preliminary to glacial and erosive action, which removed previously softened materials," was discussed in its relations to boulders, glacial drift, and the contour of glaciated regions. Pumpelly's development and extension of this doctrine to wind-erosion was noticed, and also the recent comparative studies of Reusch in Norway and in Corsica, in which similar views are enforced.

The principal points in the paper, as viewed at its close, are as follows:—

1. The evidence afforded by recent geological studies in America, and elsewhere, of the universality and the antiquity of the subaerial decay, both of crystalline silicated rocks and of calcareous rocks, and of its great extent in pre-Cambrian times.

2. The fact that the materials resulting from such decay are preserved *in situ*, in regions where they have been protected from denudation by overlying strata, alike of Cambrian and of more recent periods; or, in the absence of these, by the position of the decayed rock with reference to denuding agents, as in driftless regions, or in places sheltered from erosion, as within the St. Lawrence and Appalachian valleys.

3. That this process of decay, though continuous through later geological ages, has, under ordinary conditions, been insignificant in amount since the Glacial period, for the reason that the time which has since elapsed is small when compared with previous periods; and also, probably, on account of changed atmospheric conditions in the later time.

4. That this process of decay has furnished the material, not only for the clays, sands, and iron-oxides from the beginning of Palæozoic time to the present, but also for the corresponding rocks of Eozoic time, which have been formed from the older rocks by the more or less complete loss of protoxide bases. The bases thus separated from crystalline silicated rocks have been the source, directly or indirectly, of all limestones and carbonated rocks, and have, moreover, caused profound secular changes in the composition of the ocean's waters. The decomposition of sulphuretted ores in the Eozoic rocks has given rise to oxidized iron-ores *in situ*, and to rich copper-deposits in various geological periods.

5. That the rounded masses of crystalline rocks, left in the process of decay, constitute not only the boulders of the drift, but, judging from analogy, the similar masses in conglomerates of various ages, going back to Eozoic times; and that not only the forms of such detached masses, but the surface-outlines of eroded regions of crystalline rocks, were determined by the preceding process of subaerial decay of these rocks.

II.—Notes sur la Flore Houllière des Asturies. Par M. R. Zeiller. Mémoires de la Société Géologique du Nord. Tome Premier. Lille, 1882.

THIS memoir comprises a critical examination by M. R. Zeiller of about fifty species of fossil plants, chiefly Ferns and Sigillaria, collected by Dr. C. Barrois from the Coal-measures of Asturias. M. Zeiller has compared all the specimens with similar or allied forms from the Coal-measures of France, England, and America, and has identified all of them with previously known forms.

The Coal-measures of Asturias are referred to three basins, the central, northern and western, but the plants occur at different horizons.

According to M. Zeiller, the plants received from Dr. C. Barrois indicate two great stages in the Coal-formation of the Asturias, and in this respect he is corroborated by M. Grand' Eury, who has also seen the specimens. The upper stage is represented at Tineo, Lomes, Arnao, and Ferroñes, the deposits of Tineo and Lomes belong to the sub-superior, at least those of Tineo to the upper part; those of Arnao and Ferroñes occupy a position perhaps a little higher, that is to say, at the top of the series. The middle coal division is represented throughout the central basin and at Santo-Firme, the beds at Mieres, Sama, Ciano, etc. (central basin) belong to the upper part of the middle stage, and those of Santo-Firme to the middle, if not to the lower middle stage. The lower coal division is seen in the Cordal de Lena to the west of Pola de Leña. As to the small basins of Quiros and Onis, the specimens did not permit the age to be fixed, from their small numbers and the absence of any characteristic species. This memoir was intended to form part of the "Recherches sur les Terrains Anciens des Asturies," etc. (see Preface, p. 7), in which work, pp. 551–570, Dr. Barrois has fully described the characters and position of the Coal-fields of Asturias. J. M.