FIG. 7. *Neritopsis Morrisianus*, H. Woodw. Clay-marl, Tertiary, *loc. cit.*
„ 8. *Melania subfossilis*, H. Woodw. Tertiary, „
„ 9. „ *rivularis ?* Philippi. „ „
„ 10. „ ? (cast of). White Tertiary Clay-marl, „
„ 11. „ *pyramis*, Benson. Tertiary, „
„ 12. „ *sublactea*, H. Woodw. „ „
„ 13. „ *costata*, var. *glabra*, H. Woodw. Tertiary, „
„ 14. *Dentalium*, sp. Tertiary Clay-marl, „

NOTICES OF MEMOIRS.

I.—"LIMESTONE AS AN INDEX OF GEOLOGICAL TIME." By T. MELLARD READE, C.E., F.G.S. [From the Proceedings of the Royal Society, No. 192, 1879.]

THE geological history of the globe is written only in its sedimentary strata, but if we trace its history backwards, unless we assume absolute uniformity, we arrive at a time when the first sediments resulted from the degradation of the original crust of the globe.

There is no known rock to which a geologist could point and say "that is the material from which all sedimentary rocks have been derived," but analogy leads us to suppose that if the earth had an igneous origin, the original materials upon which the elements first began to work were of the nature of granite or basalt.

From a variety of considerations drawn from borings, mines, faults, natural gorges and proved thicknesses of the strata of certain mountain chains, the author arrives at the conclusion that the sedimentary crust of the earth is at least of an average actual thickness of one mile, and infers from the proportionate amount of carbonates and sulphates of lime to materials in suspension in various river waters flowing from a variety of formations, that one-tenth of the thickness of this crust is calcareous.

Limestone rocks have been in process of formation from the earliest known ages, but the extensive series of analyses of water made by Dr. Frankland for the Rivers Pollution Commission, shows that the later strata in Great Britain are much more calcareous than the earlier. The same holds true of the continent of Europe, and the balance of evidence seems in favour of the supposition that there has been on the whole a gradual progressive increase or evolution of lime. The "Challenger" soundings show that carbonate of lime in the form of tests of organisms is a general deposit characterizing the greater part of the ocean bottoms, while the materials in suspension are, excepting in the case of transport by ice, deposited within a distance of 200 miles of land.

This wider distribution in *space* of lime, the author thinks, must also profoundly influence its distribution in *time*, and he shows this by example and illustration. It can also be proved to demonstration that the greater part of the ocean bottom must at one time or another have been land, else the rocks of the continents would have become gradually less, instead of more, calcareous.

Thus the arguments drawn from the geographical distribution of animals are reinforced by physical considerations.

The author goes on to show that the area of granitic and volcanic rocks in Europe and the part of Asia between the Caspian and the Black Sea, as shown in Murchison's Map of Europe, is two-twenty-fifths ($\frac{2}{25}$) of the whole; much of this is probably remelted sediments, and some of the granites the product of metamorphism.

From considerations stated at length, it is estimated that the area of exposures of igneous to sedimentary rocks would be for all geological time liberally averaged at one-tenth ($\frac{1}{10}$) of the whole.

These igneous rocks are either the original materials of the globe protruded upwards, or they are melted sediments or a mixture of the two.

The only igneous rocks we know of are of the nature of granites and traps. If these rocks do not constitute the substratum of the earth, and all known rocks, igneous as well as sedimentary, are derivative, either geological time is infinite, or the rock from which they are derived is, so far as we know, annihilated geologically speaking, and we have no records of it left.

If we assume the latter as true, the past is immeasurable, but in order to arrive at a minimum age of the earth, the author starts from the hypothesis that the fundamental rocks were granitic and trappean.

From eighteen analyses by Dr. Frankland, it is shown that the water flowing from granitic and igneous rock districts in Great Britain contains on an average 3·73 parts per 100,000 of sulphates and carbonates of lime.

The amount of water that runs off the ground is given for several of the great continental river basins in Europe, Asia, Africa, and America. The annual depth of rain running off the granitic and igneous rock areas, taking into consideration the greater height at which they usually lie and the possibility of greater rainfall in earlier ages, is averaged at 28 inches, and the annual contribution of lime in solution in the forms of carbonates and sulphates at 70 tons per square mile.

With these elements, and giving due weight to certain physical considerations that have been urged in limitation of the earth's age, the author proceeds to his calculations, arriving at this result, that the elimination of the calcareous matter contained in the sedimentary crust of the earth must have occupied at least 600 millions of years. The actual time occupied in the formation of the groups of strata as divided into relative ages by Prof. Ramsay, is inferred as follows:—

	Millions of Years.
Laurentian, Cambrian, and Silurian	200
Old Red, Carboniferous, Permian, and New Red	200
Jurassic, Wealden, Cretaceous, Eocene, Miocene, Pliocene, and Post-Pliocene	200
	600

The concluding part of the paper consists of answers to objections. The author contends that the facts adduced prove geological time to be enormously in excess of the limits urged by some physicists, and ample to allow on the hypothesis of evolution for all the changes which have taken place in the organic world.

II.—Fossil Forests of the Yellowstone Park.

MR. W. H. HOLMES has given a brief but interesting account of the volcanic Tertiary beds of the Yellowstone region (Bull. U. S. Geol. and Geog. Survey of the Territories, vol. v. p. 125), which are stated to cover or to have covered an area of not less than 10,000 square miles. The chief materials consist of volcanic fragments apparently distributed by water, and now form breccias, conglomerates, and sandstones, and contain an abundance of silicified wood. Where typically developed, as in the valley of the East Fork, they have a thickness of 5,000 feet, and rest upon eroded surfaces of granitic and Palæozoic rocks. The lowest observed occurrence of these beds is in the valley of the main Yellowstone, between the first and second cañons, at an elevation of about 5,000 feet above the level of the sea. They appear to be destitute of animal remains, but the greater part of this immense group of strata is filled with the silicified remains of a multitude of forests. The roots and stems are found *in situ*, and prostrate trunks are of frequent occurrence, besides branches, leaves, and fruits. These old forests are well exposed at successive levels in the 2,000 feet of strata exposed on the north face of Amethyst Mountain, and from the character of the vegetation, Prof. Leo Lesquereux considers the strata to belong to the Lower Pliocene or Upper Miocene. In many cases the wood is completely opalized or agatized, and the cavities are filled with beautiful crystals of calcite, quartz, and amethyst. J. M.

III.—Report on the Stormberg Coal-field. By Mr. E. J. Dunn. 4to. pp. 36. (Solomon & Co., Cape Town, 1878.)

MR. DUNN describes the constituent strata of the Stormbergen as—at top—1. Volcanic: lavas, tuff, agglomerate, ash-beds, and amygdaloids, with volcanic bombs in sandstone, about 400 feet. 2. Cave-sandstone: buff-coloured, pinkish, greenish, white and grey, fine-grained, thick-bedded sandstone; about 150 feet; with fragments of Sauroid bones. 3. Red beds: friable, red and purple, arenaceous shale, and similar sandstone, mottled green, alternating with grey felspathic sandstones, also conglomerate (p. 8); about 600 feet; with Sauroid bones; and fossil wood in the lower beds, scarce. 4. Coal-measures: grey and light-coloured sandstones, generally felspathic, alternating with shales, in which coal-seams occur, and conglomerates; about 1,000 feet; carbonized plant-remains abundant in the sandstones, ferns in the shales; fossil wood abundant; fossil bones very rare. Doleritic dykes penetrate the whole series. The "Stormberg" strata, he says, continue throughout the Drackensberg range, and the series is as strongly marked near Harrismith as in the Stormbergen. They lie conformably on red, greenish, and grey shales, with grey sandstones, rich with Dicynodont and other reptilian remains. Mr. Dunn separates the latter series, as "Upper Karoo Beds," from the former (as "Stormberg Beds"); but why the whole should not remain, as heretofore, as parts of the great "Karoo Formation" of A. G. Bain, is not at all clear.

The Coal-bearing beds of the Stormberg as seen on the north

side (Albert), and the conditions of working, are described at pages 5 and 6 and 16–33. The seams of coal are not numerous nor thick; the aggregate being not more than 6 feet 6 inches, at Bushman's Hoek and the Indwe River, with 4 feet more represented by "one or two thin seams of inferior coal, occupying a higher position in the series," a few miles to the south. Ferns from the coal-shales are identified (p. 19) with *Pecopteris odontopteroides* (p. 11), *Cyclopteris cuneata*, and *Tæniopteris Daintreei* of Queensland.

The "Red Beds" are described at pages 7–9. The "Cave Sandstone," described at pages 9 and 10, forms conspicuous precipices, being at some places a solid freestone more than 150 feet thick, almost without any lines of bedding. Water, running over its edge, or oozing out from beneath, forms the numerous caves to which it owes its name. One of these is 330 feet wide at the entrance, 144 feet deep, 60 feet high at mouth, lessening to nothing at the back of the cave. The kloofs (gorges), krantzes (precipices), kops (little hills), blocks, caves, and fantastical masses (pulpit-rocks, etc.), of this sandstone give rise to picturesque and sometimes grand scenery. The felspathic material in this sandstone, acted on by infiltrating rain-water, gives the calcareous stalagmite (drip-calc) seen in some of the caves and krantzes. In this sandstone, as in the "Coal-measures" and "Red-beds," ripple-marks and mud-cracks are present, also "tracks of crustaceans."

The "Volcanic rocks" are described in detail at pp. 10–16. "Two of the cores still preserve a crater-like form;" these are of very great interest, and are "Glat Kopjes" and "Telemachus Kop." Pipes, throats, flues, plugs, etc., of old volcanos are also met with among the "Stormberg beds" in the Nieuwveldt and Karreebergen (near Caernarvon). The numerous dykes of igneous rock all over the region are referred to; also the agate-gravel of many rivers of South Africa is noticed as having been derived from the amygdaloids; and the origin of "pipe-agate," as due to the uprise of steam in hot vesicular and siliciferous lava from the damp ground over which it flowed, is concisely stated among other interesting facts connected with this division of South-African Geology.

We may mention that in the "Cape Monthly Magazine," new series, vol. ii. 1873, p. 60, is Mr. Dunn's earlier report on the Stormberg Coal; and that Mr. Evans, of Queenstown, has given some useful notes on the Stormberg Coal as known in 1870 (see the "Mining Journal," January 14, 1871); also that Mr. G. W. Stow, F.G.S., has described and illustrated the Geology of Dordrecht and other places north and south of the Stormberg, in the Quart. Journ. Geol. Soc. vol. xxvii. 1871, pp. 523, etc.

In conclusion, Mr. Dunn states (p. 32):—"The tract of country over which coal-outcrops may be expected to occur on the South slopes of the Stormberg, lying between Bushman's Hoek and the Indwe, has not been examined. From the position the coal-measures occupy, it is clear that coal-outcrops will be found right round the base of the Drackensberg, and equally clear that the seams are thicker and the quality better the further they occur to N.E. from the

Stormberg. In Natal, at Biggar's Berg, is a seam of coal, eight feet thick, of better quality than the Stormberg coal. In the Transvaal equally thick seams of superior coal are known in the High Veldt. A few outcrops are known in the Free State. Properly directed explorations would result in tracing the outcrops through Kaffirland, Natal, the Transvaal, and Free State. In the higher parts of Basutoland, and, in fact, along the higher portions of the Drackensberg chain and its spurs, no coal will be found; the seams do not occur at such altitudes." T. R. J.

IV.—Report on the Camdeboo and Nieuweldt Coal, Cape of Good Hope. By E. J. Dunn, Esq. 4to. pp. 24, with several Sections and Plans. (Solomon & Co., Cape Town, 1879.)

THE occurrence of two sets of Coal-bearing beds on the N.E. margin of the Stormberg (near Bushman's Hoek), north of Queenstown,—one of probably old "Carboniferous" age, and the other belonging to the upper part ("Stormberg") of the great Karoo Series,—was indicated in the Quart. Journ. Geol. Soc. 1871, vol. xxvii. p. 52; and, though the Report above noticed does not support that view, something like it is now proved to be the case at about 150 miles W. by S. from Queenstown. Mr. Dunn has found an exposure (*inlier*) of some underlying coal-bearing (anthracitic) strata, distinct from the surrounding and unconformable Karoo Beds, at Buffel's Kloof, on a spur of the Camdeboo Mountains, between Graaf-Reinet and Beaufort West; and again at Brandewyn's Gat, by the Leeuwe River, on a spur of the Nieuwveldt, 36 miles N.W. of Beaufort West, and 100 miles W. of Buffel's Kloof. By making careful sections of the strata between Beaufort and Graaf-Reinet, and by examining the sections opened out by the new railway running S.W. from Beaufort, across the Dwyka, Bloed, and Buffel's Rivers and the Wittenberg range, Mr. Dunn has fully explained the relation of the horizontal Karoo series as unconformable to the underlying tilted, folded, and broken "Ecca Beds," with their inclosed and conformable "Dwyka Conglomerate" (Dunn). This remarkable rock, once thought to be of igneous origin ("Trap-breccia," etc.), is now known to be composed of dense sandy mudstone and blocks, and to be probably of glacial origin. Having thus successfully traced these Ecca Beds, from the (Devonian or Carboniferous) sandstones of the Witteberg, with which they are conformable, to the Camdeboo district, Mr. Dunn shows good reason why the inlier of highly inclined coaly rocks under the horizontal Karoo beds there are part of the Ecca group; and the more so because anthracite and a highly carbonaceous limestone occur in one part of that group of strata near Buffel's River on the Beaufort and Cape-Town line of railway.

The author, however, is not correct in stating that the Karoo Beds have always been supposed to be conformable to the Ecca Beds. In 1857 and 1858 ('Eastern Province Monthly Magazine,' No. 17, December, 1857, p. 187, and Quart. Journ. Geol. Soc. vol. xv. pp. 197, 198) the late Dr. Rubidge argued that in the Eastern Province of Cape-Colony the "plant-beds of Ecca" (the lower portion, at

least) were of *Devonian* age, that they did not belong to the Karoo series, and that the latter abutted against them unconformably; and these conditions are expressed in Mr. Pinchin's sections in the Quart. Journ. Geol. Soc., vol. xxxi. 1874, p. 106, pl. 4.

At Buffel's Kloof the diggings and shaft clearly show that one or more rather thick seams of coal (anthracite) in the underlying inclined beds have been broken and crushed by a fault, and even forced up into the higher fissures contained in the overlying horizontal Karoo beds, which do not hereabouts contain coal. The shales in which the coal is bedded contain "Glossopteris and Calamites." The value of these fossils in proving the exact age of the bed depends on many circumstances; and, although not quite so good as the *Lepidodendron* and *Sigillaria* from the northern margin of the Stormberg, yet *Calamites*, at least, evidently belong to beds below the Karoo Series, and *Glossopteris* may be old "Carboniferous," as in Australia.

Ecca shales with plant-remains in the Eastern Province, and fossil wood on the Pataties and anthracite on Buffel's River, in the West, indicate this to be a carbonaceous formation. Mr. Dunn suggests that there may be plenty of good coal in the covered-up "Ecca Beds" of the Camdeboo and neighbouring hills, to be found by judicious boring; and, although the exposures now known show only crushed anthracite, not only the crushing, but the metamorphic change from coal (hydrocarbon) to anthracite (carbon) may there be due, as elsewhere, to local pressure and disturbance.

The descriptions and sections in this Report elucidate the nature and relative positions of the Ecca Beds (pages 6–10), and of the lower portion of the Karoo series (pages 10–24), omitting the Stormberg portion, well described in the foregoing Report, very satisfactorily, and thus add very much to our knowledge of South-African Geology.

T. R. J.

REVIEWS.

I.—Chemical and Geological Essays. By Thomas Sterry Hunt, LL.D. Second edition. (London, Trübner & Co., 1879).

THE recent issue of a second edition of Dr. Sterry Hunt's Chemical and Geological Essays, which first appeared as a separate volume in 1875, affords a fitting opportunity for noticing some of the questions with which the author is so well qualified to deal. The work consists of a series of papers published in various scientific journals during the last twenty years, which are now reproduced more or less verbatim, with short introductory notes occasionally prefixed by way of explanation. There are twenty essays in all, dealing with a variety of subjects, most of which may be grouped under the following heads:—

1. Chemical and dynamical speculations on the early condition of the planet, and on subsequent volcanic phenomena.
2. History of the crystalline rocks.
3. Essays in chemical geology not directly related to either of the above subjects.