the Coal-measures. There is some reason to believe that in this area one or more lakes existed in preglacial times.

The boulders in the drifts at Colomendey are chiefly limestone, though felstone is likewise present. Many of the smaller stones consist of vein quartz and Wenlock shale or grit. The fact that many of the stones must have come from some distance, and a few of them (the felstones) from a great distance, is sufficient to show that the drifts could not have been deposited by a cause limited to this particular hollow, and that here they must either have been arrested, while in exposed situations no deposition took place, or that a more extensive deposition was followed by denudation, which left this patch on account of its being protected. The preglacial white clay is probably a freshwater deposit. The overlying drifts must have been accumulated by the sea, floating ice, land ice, or by these three agencies combined. It is worthy of remark that many of the small stones in the blue clay are much rounded, as if they had been subjected to attrition under water. This clay evidently belongs to the oldest drift yet discovered in the north-west of England and Wales. On washing it, its structure is found to differ from that of the lower brown clay of the plains, and likewise from that of the pinnel of the Lake District. With a hummocky and much denuded surface, a similar blue clay is found underlying these deposits on the coast of North Wales and in Cumberland.[1]

NOTICES OF MEMOIRS.

I.—The Secondary Rocks of Scotland. (Second Paper.) On the Ancient Volcanos of the Highlands, and their Relations to the Mesozoic Strata.[2]

By John W. Judd, F.G.S.

Introduction.—The vestiges of the Secondary strata on the west coast of Scotland have been preserved, like the interesting relics of Pompeii, by being buried under the products of volcanic eruptions. The deposition of the Mesozoic strata in this district was both preceded and followed by exhibitions of volcanic phenomena on the grandest scale; and it is only by a careful study of the records of these two great periods of igneous activity that we can hope to understand the remarkable relations of the fragments of the intermediate sedimentary formations, or to account for the peculiarities which they present.

That the rocks forming the great plateaux of the Hebrides and the north of Ireland are really the vestiges of innumerable lava-streams, is a fact which has long been recognized by geologists. That these lavas were of *subaerial* and not *subaqueous* origin, is proved by the absence of all contemporaneous interbedded sedimentary rocks, by the evidently terrestrial origin of the surfaces on which they lie, and by the intercalation among them of old soils,

[1] See Geol. Mag. Vol. VII. Oct. and Dec. 1870, and Vol. IX. January, 1872.

[2] Abstract of a paper communicated to the Geological Society on January 21, 1874.

forests, mud-streams, river-gravels, lake-deposits, and masses of unstratified tuffs and ashes. From the analogy of existing volcanic districts, we can scarcely doubt that these great accumulations of igneous products, which must originally have covered many thousands of square miles, and which still often exhibit a thickness of 2000 feet, were ejected from great volcanic mountains; and a careful study of the district fully confirms this conclusion, enabling us, indeed, to determine the sites of these old volcanos, to estimate their dimensions, to investigate their internal structure, and to trace the history of their formation.

The Tertiary Volcanos.—The petrology of the Western Isles has been made the subject of careful study by Professor Zirkel, of Leipzig, to whose investigations we are very deeply indebted. The Tertiary igneous rocks may be classified, according to their ultimate chemical composition, into two series, known as the acid and basic igneous rocks. In each of these series the proportions of the several ingredients in its various members are almost identical; but in structure the rocks of either series vary from the coarsest crystalline aggregates to the most perfect glass. The acid series consists of granite, felsite, felstone, and pitchstone; the basic of gabbro, dolerite, basalt, and tachylite; the members of either series exhibit innumerable varieties, and pass into one another by the most insensible gradations. The igneous rocks of both classes form *lava-streams*, often of great thickness and extent, and exhibiting many interesting peculiarities of the amygdaloidal and columnar structures; *eruptive masses* varying in size from great mountain groups to the smallest dykes and veins; *volcanic agglomerates*, composed of the scoriæ and ashes ejected from volcanic vents; and *volcanic breccias* made up in great part of the fragments of the various Palæozoic and Secondary rocks through which the volcanos have burst. Among the volcanic agglomerates are found beautiful examples of the more stable of the species of minerals characteristic of the neighbourhood of volcanic vents.

The relations of these several igneous products to one another are beautifully exemplified in the Island of Mull. We here find proof that the volcanic activity of the Tertiary period commenced with the eruption of felspathic lavas and associated fragmentary materials. These were accompanied by the intrusion among the surrounding strata, which they greatly metamorphosed, of great masses of fluid rock of acid composition, and the extrusion among the other igneous products of similar liquefied materials, which consolidated into felsite and granite. The great volcanic mountains thus formed appear to have remained in a state of comparative quiescence for a vast period, during which they were subjected to great denudation, and then through their midst were forced great masses of fluid basaltic rocks, which continued to flow at intervals during enormous periods, and gave rise to streams of basalt which accumulated to the thickness of many hundreds and even thousands of feet. The great intrusive bodies of this same rock consolidated into mountain masses of gabbro and dolerite. While the earlier felspathic lavas appear to

have rarely flowed to a distance of more than ten miles from the volcanic vent, those of basaltic character often extended to distances of fifty or sixty miles, or even more. The same difference of behaviour of the two classes of lava has often been remarked in the case of existing volcanos.

Besides the volcano of Mull, we have evidence of the existence of four other great vents in the northern part of the Hebrides, namely, in the peninsula of Ardnamurchan, and in the islands of Rum, Skye, and St. Kilda respectively. In each of these a period characterized by the eruption of felspathic lavas was followed, after a considerable interval, by one during which nearly all the materials thrown out were of basaltic composition. The volcano of Mull is in a far more perfect state of preservation than the others, owing to the great amount of central subsidence which has taken place in its mass. This central subsidence appears to be strictly analogous to that which has been shown by Mr. Darwin, Mr. Heaphy, and Krug von Nidda, to have occurred in the case of recent volcanos in the Cape de Verde Islands, New Zealand, and Iceland. From an examination of the areas covered by the great Tertiary volcanos of the Hebrides, and of the interesting data afforded by the present positions of their lava-streams, etc., we are able to estimate that while the volcanos of Mull and Syke were certainly of far greater bulk than Etna, those of Ardnamurchan, Rum, and St. Kilda could have been of scarcely inferior dimensions.

There is proof that after the extinction of the five great volcanos of the Northern Hebrides and the very extensive denudation of the great plateaux composed of their lavas, there burst out a number of sporadic eruptions which resulted in the formation of comparatively small volcanic cones, analogous to the "puys" of Central France, which have been so admirably described by Mr. Poulett-Scrope. These "puys" of the Hebrides are very numerous, and are exhibited to us in various stages of preservation.

The formation of the various volcanic piles of the Western Isles was accompanied by the intrusion of innumerable igneous masses of all sizes among the surrounding older strata. The liquefied rocks of acid composition accumulated in great lenticular masses in the midst of the stratified rocks, consolidating into felsite and granite; while the heavier and more fusible basaltic materials spread between the strata in vast sheets of enormous extent, which, when cooled, formed dolerite and basalt. Besides the larger intrusive masses, the whole district around each of the volcanic vents is traversed by a wonderful plexus of dykes and veins, composed of both acid and basic rocks, some of the dykes of basic composition extending to extraordinary distances, as pointed out by Prof. Geikie. The great igneous masses, besides *disturbing* the older strata through which they have been forced, have effected a remarkable *metamorphism* in them, the amount of this metamorphism and the distance to which it extends being in each case proportioned to the bulk of the intrusive mass.

From a consideration of the whole of the evidence it appears

highly probable that the first period of igneous activity (namely, that of the eruption of felspathic lavas from the great volcanos) was contemporaneous with the Eocene sedimentary formations; the second period, that of the great and prolonged outbursts of basaltic lavas from the same vents, was certainly that of the Miocene; while the third period, or that of the formation of the "puys," may, with a great show of probability, be correlated with the Pliocene.

The igneous activity during the Tertiary period in the Northern Hebrides appears to have extended in all its magnitude, and to have exhibited similar stages in its development, far to the southwards, as is illustrated by the rocks of Arran, Antrim, and the Mourne Mountains. But even this tract, extending 400 miles from north to south, which was characterized by grand volcanic phenomena during the whole of the Tertiary period, can only be regarded as a portion of the great belt of volcanos which at that epoch extended through Greenland, Iceland, the Faroe Islands, the Hebrides, Ireland, Central France, the Iberian peninsula, the Azores, Madeira, Canaries, Cape de Verde Islands, Ascension, St. Helena, and Tristan d'Acunha, and which constituted, as shown by the recent soundings of H.M.S. 'Challenger,' a mountain-range comparable in its extent, elevation, and volcanic character with the Andes of South America. The admirable manner in which the relations between the Volcanic and Plutonic rocks are exhibited in the old volcanos of the Hebrides, renders them of special interest to the geologist; and the further illustrations of the same phenomena which are afforded to us by the relics of a still older series of volcanos, are made more clear and striking by the aid of their analogies.

The Newer Palæozoic Volcanos.—In the district of Lorn we find a great series of old felspathic lavas which, in their lower part, alternate with conglomerates and sandstones, and which, in their higher portions at least, appear to be of subaerial origin. It is evident that we have here the relics of what was once a widely spreading plateau, made up of lava-streams, like that of Tertiary age already described. These rocks were evidently formed long subsequently to the Lower Silurian strata, but before any of the Secondary sediments were deposited.

The central and southern districts of Scotland exhibit enormous masses of igneous rocks, in part at least of subaqueous origin. These exhibit a very close similarity in petrological character with the lavas of Lorn, and are shown, by the interbedded and contemporaneous fossiliferous sediments associated with them, to range in age from the Lower Old Red Sandstone to the Lower Carboniferous.

Along the whole line of the Grampian Mountains we find a number of granitic masses connected with a wonderfully complicated series of veins and dykes of rocks of similar composition. These igneous intrusions, which disturb and metamorphose the surrounding strata, are evidently, as shown by Murchison and Geikie, of far later date than the Lower Silurian, but are earlier than the Secondary strata.

Concluding, as we cannot avoid doing, that these igneous intrusions and the subaerial and subaqueous lavas of similar composition

were all formed during the Newer Palæozoic periods, we are led to the presumption of their probable former connexion with one another. By the phenomena presented at a number of interesting points, such as Beinn Nevis and Glencoe, where the granite rocks and the lavas are so associated with one another and with masses of volcanic agglomerate as to demonstrate the identity of their origin with that of the similar masses of Tertiary age in the Hebrides, this presumption is converted into certainty. The Newer Palæozoic period of volcanic eruption terminated, like that of the Tertiary epoch, by a grand development of "puys" during the Carboniferous and Permian periods. Of these, the celebrated Arthur's Seat, near Edinburgh, and many similar cases in Fife and the Lothians, may be cited as examples.

Conclusion.—It appears that during the Newer Palæozoic and the Tertiary periods, the north-western parts of the British archipelago were the scene of displays of volcanic activity upon the grandest scale. During either of these, the eruption of felspathic lavas, etc., preceded, as a whole, that of the basaltic; and in both, the volcanic action was brought to a close by the formation of "puys." The range of Newer-Palæozoic volcanos arose along a line striking N.E. and S.W.; that of the Tertiary volcanos along one striking from N. to S.; and each appears to have been connected with a great system of subterranean disturbance. It is an interesting circumstance that the epochs of maximum volcanic activity, the Old Red Sandstone and the Miocene, appear to have been coincident with those which, as shown by Prof. Ramsay, were characterized by the greatest extent of continental land in the area.

The Secondary strata were deposited in the interval between the two epochs of volcanic activity, and the features which they present have been largely influenced by this circumstance. Apart from this consideration, however, the volcanic rocks of the Highlands are of the highest interest to the geologist, both from their enabling him to decipher to so great an extent the "geological records" of the district, and from the light which they throw upon some of the obscurest problems of Physical Geology.

II.—Brief Abstracts for 1873.

The following Abstracts are intended to serve as the commencement of a "Record of Geological and Palæontological Literature for 1873," to embrace abstracts of all papers published abroad or in the provinces.[1]

Anon. Geological List. 1873. *2nd Rep. Winchester Coll. Nat. Hist. Soc.*, pp. 80–82.

A list of the principal sections in the neighbourhood of Winchester,

[1] The work will be carried on under the direction of a Committee appointed by the British Association, which at present consists of Mr. Henry Woodward, Prof. Williamson, Mr. F. W. Rudler, Mr. L. C. Miall, Mr. W. Topley, Mr. W. Whitaker, Mr. G. A. Lebour, Mr. W. Carruthers, and Mr. Horace B. Woodward. The co-operation of geologists is earnestly desired. Copies of papers and Transactions of Local Societies will be gladly received by the Secretary to the Committee, Henry Woodward, Edit. Geol. Mag.

with a note of the fossils that have been found in them, followed by a short "Synopsis of the Fossil Fauna."

HUTCHINSON, P. O. Submerged Forest and Mammoth Teeth at Sidmouth. *Trans. Devon. Assoc.*, vol. vi. part i. pp. 232–235.

In the winter of 1872 reefs of rocks and beds of clay that had not been seen for many years were laid bare on the coast at Sidmouth. In the alternations of clay and gravel shown there were stumps of trees, which must have grown in their present positions when the land was at a higher level than now, as they are about eight feet below high-water.

LINFORD, W. On Quarries at Beer, in Devonshire, and some of their Fossils. *Trans. Edin. Geol. Soc.*, vol. ii. part ii. pp. 181–184 (and p. 190).

Of these quarries, three are subterranean and one open. The section of the last is given as follows:—Layers of chalk, layers of sandstone, layers of freestone, and a coarse sandstone, which probably rests on greensand. All the beds belong to the Chalk, and are mostly fossiliferous. In the upper part of the Chalk with flints, a few pebbles and one small boulder have been found. The freestone is much used for building.

PARFITT, E. Annelids *versus* Raindrops. *Trans. Devon. Assoc.*, vol. vi. part i. pp. 107–110.

This is a rejoinder to a paper by Mr. T. M. Hall, wherein certain markings on some North Devon rocks were referred to the action of rain, or rather of drifting sand, during their deposition. The author argues that these markings are those of worms, from the facts that the impressions are in different directions, whilst if they had been caused by a shower they would have been in one direction; and that they occur in the rocks to a vertical depth of at least thirty feet, which, on the raindrop theory, would need a storm lasting for very many years.

PENGELLY, W. (1) The Ossiferous Caverns and Fissures in the Neighbourhood of Chudleigh, Devonshire. (2) The Literature of the Cavern at Ansty's Cove, near Torquay, Devonshire. (3) The Literature of the Caverns at Buckfastleigh, Devonshire. *Trans. Devon. Assoc.*, vol. vi. part i. pp. 46–72.

These papers, the continuation of a series on Devonshire Caverns, give a full account of what has been written on those in question, with explanatory remarks by the author. The first two caverns are ossiferous, but those at Buckfastleigh are not.

PENGELLY, W. The Granite Boulder on the Shore of Barnstaple Bay, North Devon. *Trans. Devon. Assoc.*, vol. vi. part i. pp. 211–222.

The author first notices what has been written on this boulder (a block that weighs over ten tons), and then considers the questions that it suggests. (1) As to its origin, which he concludes may be from the west of England, or may be from the north. (2) As to its transportation, which it is argued must have been brought about by ice-action. (3) As to its age, which must be far removed from

our own time, for the boulder underlies the raised beach of Barnstaple Bay. And as that beach contains shells of the same species as those now living on the coast, which are not dwarfed (as they would have been in an icy sea), it is inferred that the boulder must have been deposited long before the beach above it.

W. W.

PROCEEDINGS OF THE LITERARY AND PHILOSOPHICAL SOCIETY, MANCHESTER.

BINNEY, E. W., F.R.S. (Jan. 21st, 1873), exhibited drawings of petioles of specimens allied to *Anachoropteris Decaisnii* of Renault, of oval form, from the Lower Coal-measures of the Foot Mine, near Oldham, Lancashire. Also a plant from the Lower Brooksbottom seam of coal, allied to the genus *Anachopteris*.

PLANT, JOHN, F.G.S. (Jan. 27th, p. 113.) "Description of Minerals and Ores from Venezuela," Collected by Mr. J. M. Spence. Gold quartz, galena, copper ores, iron ores, coal, and graphite.

WILLIAMSON, Prof. W. C. (Feb. 4th), stated that the second plant described above was not a new genus, but the fruit of *Asterophyllites*.

BROCKBANK, William, F.G.S. (Feb. 18th). "Notes on supposed Glacial Action in the Deposition of Hæmatite Iron Ores in the Furness District." Hæmatite occurs (1) filling hollows in limestone, capped by glacial drift; and (2) in veins in the limestone, and in irregular pockets. The author considers the iron ore to have been transferred by the action of an ice-sheet from the place of its original occurrence, and redeposited with the glacial drift in the crevices and hollows of the limestone (1). Giving a section at Dalton-in-Furness to explain his views.

DAWKINS, W. Boyd, F.R.S. "The Results of the Settle Cave Exploration." (p. 61.) Romano-Celtic enamelled jewelry and implements, in the upper bed of the Victoria Cave, of the era preceding the conquest of West Yorkshire and Mid-Lancashire by the Northumbrians. Beneath this stratum lay six feet of angular stones with neolithic flint flakes. Below occurred a stiff clay, believed to be of glacial origin, nearly thirty feet thick, resting on an ossiferous bed, with remains of cave bear, mammoth, reindeer, etc.

BINNEY, E. W. (March 4th, p. 72), states that the plant believed by himself to belong to a new genus, alluded to by Prof. Williamson as belonging to the genus *Asterophyllites*, was described by Prof. Renault, of Cluny, as a *Sphenophyllum* (*Comptes Rendus* for 1870).

DAWKINS, W. Boyd, F.R.S. (March 18th, p. 83.) "Observations on the rate at which Stalagmite is being accumulated in the Ingleborough Cave." Three holes were bored, and gauges of brass wire gilt inserted in the base of the stalagmite, 13th March, 1873. The possible age of the "jockey cap" stalagmite was calculated in 1845 by Prof. Phillips, from observations of Mr. James Farrar, at 259 years. Mr. Dawkins found the rate of increase to be 0·2946 inch a year, and that the whole of the stalagmite and stalactites of the Ingleborough Caves may not date further back than the time of Edward the Third.

BROCKBANK, William, F.G.S. "Notes on the Victoria Cave,

Settle." Alludes to papers of Messrs. Dawkins and Tiddeman, stating the clay overlying the lower cave earth to be of glacial origin, which the author thinks improbable, the laminated clay occurring "in the cave on the surface at a point where it can only be of most recent origin, near the dome which terminates in a 'pot-hole,' by which" the clay has entered, derived from the glacial clays lying in hollows, on the surface of the ground, as are similar clays, occurring in other caverns where a theory of glacial introduction would be possible. The author also differs from Mr. Tiddeman, who ascribes the base of the talus at the entrance to glacial age, in believing it to have been formed by matter falling from above, finding in that part of the talus a smoothly rounded limestone boulder like those occurring in "pot-holes," and from other reasons, the whole resting on the original entrance to the cave, which afterwards became covered up.

Spence, Mr., F.C.S., communicated the fact to the Society that an African diamond immersed in fine clay in a small crucible, subjected to a heat, at no time beyond cherry red, entirely volatized and disappeared after three days' exposure.

Williamson, Prof. (April 1st, p. 106), alluded to the species of *Asterophyllites*, considered to belong to *Sphenophyllum* by Renault, and remarked on the very close affinity of the two genera.

Dawkins, W. Boyd (April 15th, p. 111), Secretary of the Committee of the British Association for carrying on the explorations of Victoria Cave, replies to Mr. W. Brockbank's paper, mentioned above, reiterating his belief that the cave-bed at the bottom is pre-glacial, and stating that so far from 100 tons of earth having fallen on the day of Mr. Brockbank's visit, probably the mass weighed less than a ton.

Plant, John, F.G.S. (April 21st, p. 146.) "Notes on a Fossil Spider in Ironstone of the Coal-measures." Discovered by Mr. Elliott Hollier, in ironstone nodules in Dudley Coal-field, described by Mr. H. Woodward as *Eophrynus Prestvicii* in Geol. Mag. 1871.

C. E. De R.

REVIEWS.

I.—A Brief Account of M. Delesse's Book, "Lithologie du Fond des Mers," published under the auspices of the Minister of Marine and of Public Works. (Paris: E. Lacroix, 1871.)

By G. A. Lebour, F.G.S.

M. DELESSE divides the matter of his important work into the five following parts:—

I.—*Preliminaries.*

Methods adopted in studying the deposits

Orography of France and of its submarine shores.

II.—*Principal agents of the submarine deposits.*

Organic agents

Inorganic agents
- external . . .
  - Atmosphere.
  - Fresh and brackish waters.
  - Sea.
- internal . . .
  - Subterranean waters
  - Eruptions.
  - Dislocations.