We know that deposition and denudation are inseparable cor-relatives, and that the amount of destruction done upon the older rocks is measured by the sedimentary deposits derived from their materials; but the recognition of these facts gains more than ordinary significance when we come to consider of how much of those hidden mineral treasures we prize so highly, and the extension of which we seek so earnestly, as the means of perpetuating our national prosperity, we have been deprived by the former agency.

Along the line of ground marked by the barrier before referred to as separating the marine Devonians from the fresh-water Old Red Sandstones of this district, Palæozoic rocks are described as crumpled and contorted for a breadth of many miles, and along a length of 800 miles, tilting and turning the Coal Measures back upon themselves, squeezing and folding them, so that the crown of the anticlinal is sometimes four or five miles above the level of the reversed synclinal arch to which the bottom Coal Measures descend in Belgium. One of these anticlinals presents itself at Linley, on a small scale it is true, but bearing the unmistakable impress of the forces to which it is due, and betraying to the experienced eye, the direction in which denudation has done its work. All such tilted beds must have had broken edges somewhere, and those edges once exposed to the waves, the work of denudation would commence along the line of fracture.¹

V.—NOTES ON THE BRITISH GRAPTOLITES AND THEIR ALLIES.

By CHAS. LAPWORTH, F.G.S.

1.—ON AN IMPROVED CLASSIFICATION OF THE RHABDOPHORA.

PART I.

IN the following communication I intend to give a very brief outline of some of the chief results of my investigations among British Graptolites in those departments of inquiry which are more especially connected with considerations of classification. I shall content myself with offering a concise statement of the main conclusions at which I have arrived, reserving all detail to the future, when I hope to adduce decisive evidence in support of the views here advanced. The special subjects to be noticed in this place are—the development, structure, classification, and geological distribution of that section of the *Rhabdophora* in which the complete polypary can be proved to be composed of one or more polyparies essentially similar to that in the unilateral and uniserial forms to which the name Graptolites (*Graptolithus*) is commonly applied. Those *Rhabdophora* supposed to be similar in structure to the genus *Retiolites* will be considered in conjunction, but no pretension is made to anything like the same certainty in this section. In an outline paper like the present, which may be looked upon simply as a registration of new discoveries and opinions, it becomes possible to dispense with that constant reference to the collateral labours of other investigators which strict justice demands

¹ Read before a Field-meeting of the Dudley Geological Society, held at Linley near Bridgnorth, on 17th September, 1873.

in a work of detail. All who are likely to be interested in these conclusions will notice at a glance what is original, and what has been derived from the discoveries and speculations of previous observers.

DEVELOPMENT.

A careful study and comparison of great numbers of young Graptolites from the Moffat Shales, belonging to the genera *Dicellograptus*, *Dicranograptus*, *Pleurograptus*, *Leptograptus*, *Diplograptus*, etc., has induced me to conclude that in all the bilateral and duplex species the mode of development is essentially the same. The polypary of every species which I have been able to trace satisfactorily through the earlier stages of its existence, first becomes visible as a small pointed, triangular—or rather dagger-like—"germ," which from its constant and characteristic shape I have denominated the *sicula*.¹ In the majority of the species examined the sicula is at first exceedingly minute, but it sometimes attains a length of one-fourth of an inch before it undergoes any perceptible alteration of its external aspect. The first visible change consists in the development of a solid axis in its outer wall, extending along its entire length, and prolonged as a naked filiform process beyond one or both of its extremities. A small protuberance or bud² next makes its appearance upon one of the lateral margins, usually in the immediate neighbourhood of the major extremity of the sicula, and this is gradually moulded into a theca. A similar bud is then given off from the opposite margin, but slightly in advance of the former, and from these primordial buds the two main branches of the polypary are slowly evolved by a process of continuous gemmation.

The mode of growth here described certainly obtains in most of the species appertaining to the genera named above. In *Cænograptus* and *Nemagraptus*, however, the primordial buds are given off midway between the two extremities of the sicula. In *Dichograptus* and its allies it is yet uncertain whether the remarkable non-polypiferous "funicle" peculiar to this group is formed from true buds, or whether it is not rather a dichotomising outgrowth of the major extremity of the sicula. The sicula itself normally ceases to grow after the primordial buds have originated. In rare examples of *Diplograptus* it seems to be imbedded in the proximal portion of the polypary. In a few dibrachiate species it is absorbed or becomes obsolete in old age; but in the great majority of cases it permanently retains the shape it possessed at the period of the commencement of the lateral branches, and forms a very conspicuous feature in the adult organism. It is simply this persistent sicula which constitutes the "axillary spine" in *Dicellograptus*, the "radicular bar" in *Cænograptus*, and the "radicle" in *Didymograptus* and *Phyllograptus*, etc.

In some cases, however, the sicula most certainly increases in size after the branches have been thrown off. In the genus *Leptograptus* and its nearest allies it is frequently developed into a third and

¹ The *sicula* is probably identical with that portion of the polypary which Herr Richter has termed the "foot." See Appendix.

² See Appendix.

central branch, and examples of *Diplograptus* afford evidence that it may possibly grow even more rapidly than the branches, and give origin to that terminal "vesicle" which forms so extraordinary an appendage in a few species.

I have not yet been able to work out the development of the unilateral Graptolites (*Monograptidæ*) so fully in consequence of the generally minute size of the *sicula*. I am unable to say whether the polypary in these species extends along the *sicula* as in *Diplograptus*, or whether it does not simply originate from its minor extremity, in the manner of the central branch in *Leptograptus*. Should the latter prove to be the true method of development, this circumstance, read in conjunction with the facts to be presently noticed in connexion with the vertical range of the Graptolites, enables us to summarise, the foregoing conclusions under the following general rule.

In the earliest siculate Graptolites known (*Dichograptus*, etc.), the polypary originates from a dichotomising outgrowth from the major extremity of the *sicula*; in the second type (*Diplograptus*, etc.), it is formed from two opposite buds thrown off from the lateral margins in the immediate neighbourhood of the major extremity; in the third type (*Cænograptus*, etc.) the two buds arise from points equidistant from both extremities; in the fourth stage (*Leptograptus*, etc.), in addition to the two lateral branches, a third branch is formed by the continued outgrowth of the minor extremity of the *sicula*; and finally in the last and most modern type (*Monograptus*, etc.), the two lateral buds are apparently wanting, and the polypary is developed from the minor extremity alone.

The "angle of divergence" (sicular or dorsal angle) of the two main branches of the bilateral Graptolites, varies throughout the complete circle. It may be 0° , in which case the branches grow parallel with each other distally along the line of the *sicula*, and coalesce by their dorsal surfaces, either for the whole of their length (*Diplograptus*), or for a portion of it only (*Dicranograptus*). It may be less than 180° (*Dicellograptus*); it may exceed 180° (*Didymograptus*); or it may be as high as 360° , when the branches again coalesce (*Phyllograptus*). When the sicular angle is less than 180° , the proximal end of the complete polypary is formed by the major extremity of the *sicula*; and when it exceeds 180° , it is formed by its minor extremity.

STRUCTURE.

The common portion of a polypary of *Monograptus* preserved in relief appears to be composed simply of the conjoined bases of the successive thecæ (chambers). These bud from each other in a single linear series. The budding orifices remain permanently open, and form together a continuous longitudinal tube or canal of communication for the conveyance of the common body. The line of junction of these chambers can be traced on all examples preserved in the round, completely to the *virgula*, which lies imbedded in a narrow groove impressed on the dorsal walls of the chambers. The line of junction is naturally thickened, and projects into the common canal as a rounded shelf or flange. It will obviously be found convenient

in practice to restrict the application of the term *theca* to the exterior and separable portion of the chamber,—in other words, to that which is capable of being broken off from the common portion. There is, however, no constriction or line of separation at the proximal extremity of the theca so limited, but the distinctness of each chamber is clearly visible upon the common portion itself. The natural elevation of the central parts of these chambers within the boundaries of the common canal is the cause of that peculiar waviness of the dorsal edge of the compressed polypary, which has been noticed in a few monoprionidian species. Indeed, in some forms, this elevation is so pronounced, even in the neighbourhood of the virgula, that the dorsal margin appears toothed or denticulated in the manner of a saw.

In the duplicate forms the polypary is merely composed of two of these monoprionidian polyparies placed back to back. Their dorsal walls are flattened, and coalesce into a median septum, between the two laminae of which, the duplicate virgula (which is apparently formed by the united virgulæ of the composing branches) lies imbedded. The flattening of the dorsal walls is never carried so far as completely to obliterate the distinctness of the common portions of the chambers, but the adherent faces are bent by their mutual appression into a series of waves, answering exactly in number and position to the thecæ. The two branches are so fitted together that their thecæ constitute a double alternating series in the duplicate polypary. It is this circumstance, in combination with the natural prominence of the central parts of the proximal portions of the chambers, that gives to the suture the remarkable undulation, which, conspicuous in only a very few species, is, in all probability, a structural necessity in the whole of the siculate *Diprionidæ*.

The Moffat examples of the genus *Climacograptus* of Hall, preserved in a state of relief, place beyond a doubt the duplicate nature of the polypary in this genus, as first pointed out and subsequently so ably contended for by Professor Nicholson. A very slight pressure applied along the line of the septum in these specimens is sufficient to cause the polypary to fall apart longitudinally, and thus expose to view the continuous flattened walls, the imbedded virgula, etc., as described by him, while the distinctness of the thecæ may be placed beyond question by their being easily broken off the common canal one by one, and individually examined. Compressed examples of *Climacograptus* are sometimes procured, in which the moieties have fallen asunder for a greater or less extent previous to fossilization, and specimens are not infrequent, both in this genus and *Diplograptus*, in which it seems clearly evident that the composing polyparies must have had different rates of growth.

The form *Climacograptus typicalis* (H.), examined and described by Prof. Hall (Grapt. Quebec. Group, p. 28), may possibly belong to the genus *Lasiograptus*, to be noticed hereafter.

In addition to the great section of the siculate *Diprionidæ*, there is a second section, embracing the genus *Retiolites* and its allies. Such observations as have hitherto been made on the structure of the

polyvary in these puzzling forms, afford evidence that in these genera both series of thecae open into a sub-central common canal, and that the various parts of the polyvary are strengthened by slender chitinous threads connected with the virgula. Nothing further seems needed to show that these collectively form a very distinct group from that already noticed.

Among the species usually classed with *Diplograptus* are two extraordinary types which seem to merit generic distinction. It is, moreover, impossible at present to reconcile their general structure with the previous interpretation of that of the siculate *Diprionida*. In the first of these types, which includes *Diplograptus spinulosus* (H.) and its allies, not only is each theca furnished with two long spines or fibres, extending outwards from the angles of the aperture, but the polyvary itself is ornamented in addition with two opposite, longitudinal rows of gigantic, isolated spurs, developed along the median line of the periderm at right angles with the thecae. The polyvary in these forms is first visible as a small oval disc, bristling with a host of incipient spurs, and is in its later stages, ornamented with a greatly extended single (?) filiform virgula. The generic term *Glossograptus* was proposed for a form of this group by Dr. Emmons in 1855, and although the designation can hardly be considered appropriate now that the true form of the polyvary is known, yet it ought obviously to be retained.

In the adult polyvary of the species of the second type, a slender spine is developed from the outer margin of each theca. At a small but constant distance outside the general boundary of the polyvary, this spine subdivides into (or gives off) numerous minute threads, which inosculate with those originating in a similar manner from the spines immediately above and below. These threads form a connected network or braid almost completely surrounding the polyvary. Perfect examples are excessively rare, but the specimens belonging to the group can be recognized at once, their margins being apparently furnished with minute tufts of tangled hairs. The species of this type I propose to unite in a provisional genus under the title of *Lasiograptus* (Gr. *λάσιος*, hairy, shaggy).

THE ANALYTICAL TABLE OF THE GENERA OF GRAPTOLITES, embodying the foregoing conclusions, together with the Appendix (already referred to), containing descriptions of new genera, will appear in the December Number.

VI.—HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY.¹

By Prof. T. STERRY HUNT, LL.D., F.R.S.

(Continued from p. 461.)

WE have already noticed that Barrande, as early as 1852, gave the name of Primordial Silurian to the rocks which, in Bohemia, were marked by the first fauna; although he, at the same time, recognized this as distinct from and older than the second fauna, discovered in the Llandeilo rocks, which Murchison had declared to

¹ Reprinted from the "Canadian Naturalist," new series, vol. vi. no. 3, p. 304.