

constitution, to the surface rocks with which we are acquainted, and an inner core which differs in one or both of these characters. Etymologically the word "geology" should apply equally to the study of both these regions, but, for convenience and from the limitation of the individual human mind, it is usually confined to the problems presented by the rocks composing the crust, while those of the deeper regions lie outside its scope.

Such, briefly, are the conclusions which may be drawn from the sciences of terrestrial observation. The statement, I know, is incomplete and imperfect; some at least of the conclusions will doubtless be traversed and regarded as incompatible with the results obtained from other lines of research, but in their main features of the threefold division of physical condition and the twofold division of chemical composition they seem to me so well founded that the burden of proof lies with those who would traverse, rather than with those who are prepared to accept, them.

V.—NOTES ON AMMONITES.

By L. F. SPATH, B.Sc., F.G.S.

I.

THE following notes were compiled, for the most part, some years ago, but their publication in the present form suggested itself to the writer on the perusal (during a short "leave" from active service) of a number of recent papers on Ammonites, principally Professor Swinnerton and A. E. Trueman's study of the "Morphology and Development of the Ammonite Septum".¹ The main part of that inquiry is devoted to the development of the septum, illustrated by successive "septal sections", and it is claimed that where sutural development cannot be worked out, "septal sections" will to some extent serve as a substitute. The writer has no intention of discussing the usefulness of "septal sections"; but some of the suggestions put forward, and conclusions arrived at, by the authors, as well as certain opinions, which they adopt from other workers on Ammonites, invite critical examination. Since, in the present paper, other recent work on the morphology and physiology of the Ammonite septum and suture-line, not yet embodied in textbooks, is also included, and since the writer ventures to put forward opinions that differ in many essentials from the views of both textbooks and other authors, it is hoped that the paper may prove of general interest.

THE FORWARD BULGE OF THE SEPTUM.

Swinnerton and Trueman give interesting contoured plans of the second and of the adult septum of *Dactylioceras commune*, Sowerby sp., and graphs illustrating the average profile of these two septa, and restate that "on the whole the second septum tends to be concave rather than convex forwards" (p. 37), and that "it appears that the [adult] septum as a whole is convex forwards" (p. 32). Professor

¹ Quart. Journ. Geol. Soc., vol. lxxiii, pt. i, pp. 26-58, pls. ii-iv, 1917.

Blake's suggestion is adopted, that this forward convexity of the later septa (so conspicuous only because the average section of an Ammonite happens to pass through the ventral and dorsal lobes) is evidence of pressure from behind the animal; and it is assumed that "in Ammonites the vigour of secretion may have been so great that the gas exerted sufficient pressure upon the soft mantle to make it bulge forward while the septum was being deposited" (p. 33).

The influence of this pressure is referred to in connexion with the modification of the adult suture-line in Dactyloidea, where among other "ageing" characters of the later suture-lines the authors mention the "more intricate wrinkling of the minor details". They state (p. 39), "This complexity is strongly suggestive of the wrinkling of a collapsing or flaccid bladder, as opposed to the simpler and more turgid outlines of the folioles in earlier septa, and suggests a diminution in the vigour of gas-secretion in the declining period of life." The association of complexity with decline may seem contradictory; for the authors, speaking phylogenetically, say (p. 51) "during retrogression this fringe [of complicated frilling] is gradually lost". This complexity is not so apparent, however, as the other "ageing" characters mentioned, namely the "decrease in the antero-posterior range of the lobes and saddles" or "crumbling down of the apices of the saddles to approximately the same plane", and the "swinging forward of the umbilical portion of the suture-line" (p. 39). Following S. S. Buckman, the authors consider the Dactyliocerates to be "evidently a decadent offshoot of *Caeloceras*", though to the writer neither the decadence of this most flourishing family nor the derivation from the Carixian *pettos*-group, to which the genus *Caeloceras* must be restricted, is evident. They see in them "the phenomena which characterize the first stages in the simplification of the suture-line, a simplification that is carried to such extremes in Cretaceous Ammonites" (p. 40).

CORRELATION OF SUTURE-LINE AND WHORL-SHAPE.

Attention must be drawn in this connexion to the close relationship that exists between the suture-line and the shape of the whorl. In the Dactyloidea the tendency is towards loosely coiled, more or less cylindrical whorls, and in the evolution from a cadicone ancestor, through depressed whorls, to the slightly involute shell of the *Dactylioceras* figured by Swinnerton & Trueman, the suture-line would adapt itself to the altered whorl-shape. Zittel¹ stated: "When the whorls are circular one observes ordinarily only a few lobes, and in that case they are of nearly equal dimensions (*Lytoceras*); upon a wide ventral area the external lobe and external saddle acquire considerable dimensions; the flatter the sides are and the thinner the ventral part, the larger the size of the lateral lobes and lateral saddles, and the more numerous the auxiliary lobes." Pfaff² mentions that "compressed forms would show the greatest differentiation of their suture-lines in the lateral region and in the

¹ *Handbuch d. Pal.*, vol. i, 2, pp. 332, etc., 1881-5.

² "Form u. Bau d. Ammon.-Sept., etc.": *Jahresb. Niedersächs. Geol. Ver.*, vol. iv, pp. 221-2, 1911.

principal lobe; depressed forms on the other hand externally and internally. Again, as during growth the septal surface increases at the relatively quickest rate on the external side, differentiation must begin here".

On examination of the three types of Ammonites chosen by Swinnerton & Trueman, it is found that in *Tragophylloceras Loscombi*¹ with wide lateral areas, the first lateral lobe and first lateral saddle show the greatest differentiation; and in the depressed *Sphaeroceras Brongniarti* it is the external saddle. In the Dactyliocerate suture-lines figured by the authors on p. 39 the widest-ventered form (fig. 4) has the external saddle strongly developed, and it has already been remarked that there is a tendency to equalize the size of the saddles on the adoption of a more cylindrical whorl.

It should be pointed out, however, that there are what may be called family peculiarities that modify the suture-elements in certain cases. They are of value in tracing the affinities of homœomorphs, such as the perfectly similar oxycones that appear at so many horizons. The Triassic *Entomoceras denudatum*, Mojsisovics, and the Cretaceous *Garnieria* e.g. had been put into the strictly Lower Liassic genus *Oxynoticeras* by different authors. Although, in the mechanical adjustment to a wider side, either by the spreading-out of the lateral lobes and saddles or by the addition of auxiliary or adventitious elements,² similar suture-lines may result in different stocks, yet the modified shells can generally be referred to their ancestral stock by means of some retained family characteristic.

Again, the genera *Macrocephalites*, *Cadoceras*, *Pachyceras*, *Tornquistes*, and *Erynnoceras*, with wide ventral areas, all have a very large external saddle. In *Chamoussetia*, a smooth and keeled descendant of the *Cadoceras* stock, what may be considered the natural adjustment of the suture-line to this type of shell is shown; yet in the later keeled *Quenstedticeras* and *Cardioceras* the suture-line at first still is more or less similar to that of the fat ancestral forms. This may partly be retention of the family character or hastening of the development of the keel; but it may be assumed that ornament and other mechanical expedients for the increase of the solidity of the shell also influence the septal edge. This may account for the changing width of the external saddle in *Macrocephalites* and *Tornquistes* to which R. Douvillé³ has drawn attention. *Tragophylloceras ibex*, with strong ornament, has a simplified suture-line as compared with the smooth Phyllocerates⁴ of

¹ The specimen used by Swinnerton and Trueman for their series of septal sections (fig. 13 on p. 46) shows the small terminal leaflets of the *ibex* group.

² Pictet (*Traité de Paléont.*, p. 669) pointed out already in 1854 that the inflated "varieties" of a species often differed from the compressed ones in the number of the accessory lobes, and that modification of the umbilicus produced the same result.

³ "Étude sur les Cardioceratidés de Dives, etc.": Mém. No. 45, Soc. Géol. France, Pal., i, 19, fasc. 2, p. 14.

⁴ Additional work on the various features of the suture-line has demonstrated to the writer the impossibility of basing the separation of genera which other

the ancestral stock. In *Baculites* again, where, theoretically, the suture-elements should be equal, there is a fair amount of variation, caused probably by the differences in cross-section, ornament, and thickness.

It may be added here that certain Lower Aptian developments of the Upper Barremian *Leptoceras* (*trispinosum*-group) show how with the gradual straightening out of the shell the suture-elements become more nearly equal. One such form is e.g. "*Hamites*" *nodosus*, v. Koenen,¹ which, of course, has nothing to do with the Albian genus *Hamites*, just as "*Bochianites*" *undulatus*, v. Koenen,² cannot be attached to *Bochianites*, a homœomorphous development of an earlier perisphinctoid Hoplitid. The suture-line of these hoplitid Crioceratids then assumes the aspect of that of the lytoceratid Macroscaphitidæ, and the distinction between these two important families becomes very difficult.

CORRELATION OF SUTURE-LINE, ATTACHMENT TO SHELL AND MODE OF LIFE.

Another factor has to be considered here. It appears probable that in Ammonites, as in the recent *Nautilus*, the shell-muscle could easily be detached from the shell when the animal moved forward a certain space to form a fresh chamber, and that, as there would have been considerable risk of the shell falling away from its inhabitant, the folded posterior portion of the Ammonite animal with its lobes and saddles afforded the means of holding on, a function performed in *Nautilus* by the strong central siphuncle.³ When a stock like *Baculites*, in addition to its tendency to equalize the suture-elements of its straight shell, also shows simplification of the suture-line, it may be assumed that it represents an adaptation to a benthonic mode of life which its form alone would indicate. For *Lytoceras* itself, "often as thin as paper and clear as glass, with feeble ornament, i.e. characters that clearly remind one of adaptive forms of nectonic Gastropods of the high seas, *Atlanta*,"⁴ and the delicate and smooth shells of Phylloceratidæ and Arcestidæ do not generally show simplification of the suture-line. In the latter, and also in most oxynote shells, so admirably adapted for an actively swimming mode of existence, the need for secure attachment of the animal to its shell was probably greater than in benthonic crawlers.

In those one-sided Ammonites of the Lias, called *Turrilites* by d'Orbigny, which, unlike Buckman⁵ I would consider to be such characters and especially geological occurrence would appear to connect (in this case *Tragophylloceras* and *Rhacophyllites*) on the comparatively insignificant difference in the endings of the external saddle.

¹ "Ammonitiden des Norddeutschen Neocom.": Abh. Preuss. Geol. Landesanstalt, N.F., Heft xxiv, p. 393, pl. xxxv, fig. 13.

² Ibid., p. 398, pl. liii, figs. 11, 13, 14.

³ See E. A. Smith, "Note on the Pearly Nautilus," Journ. Conch., Oct., 1887; and Foord, *Cat. Foss. Ceph. Brit. Mus. (Nat. Hist.)*, pt. i, pp. xi, xii, 1888.

⁴ Diener, "Lebensweise u. Verbreitung d. Ammoniten": N. Jahrb. Miner., etc., ii, pp. 67-89, 1912.

⁵ "Vererbungsgesetze und ihre Anwendung auf den Menschen": Darwinist. Schriften, I, vol. xviii, p. 22 (214), 1893.

adaptations to a benthonic existence, the suture-line is not affected. But in such aberrant types as *Cochloceras*, *Rhabdoceras*, and *Choristoceras*, where the reduction of the septal edges to great simplicity is accompanied by modifications of the coiling, the adaptation to a different mode of life can scarcely be doubted. Professor J. P. Smith¹ calls these "reversionary" types; but if the reduction of the suture-line and uncoiling were reversionary to a primitive type, they should be preservative. The writer would also look upon *Œcoptychius Christoli*, Beaudouin, sp., *Popanites patturatensis*, Greppin, sp., and similar forms as aberrant, benthonic types.

"PHYLOGERONTIC" SUTURE-LINES. CORRELATION OF SUTURE-LINE AND ORNAMENT.

With regard to the "reduction" of the suture-line, distinction has to be made between such simplification as is shown in many individual Ammonites, where the last few septa may be simpler and be associated with an (equally sporadic) approximation. This is a growth-phenomenon of the individual. The formation of septa probably ceased when maturity was reached and the character does not become "phylogerontic"; for the stock may continue to elaborate its suture-line. Or, again, in the broad stream of development of a whole family, one branch, under local influences or owing to a tendency to diversity, may modify or simplify its suture-line. It is clear that if whorl-shape and suture-line (and of course also the other characters of the shell) are as closely interconnected as the writer believes, a form like *Hudlestonia* must adapt the suture-line of its probable ancestor *Phlyseogrammoceras* to an oxynote shell, with wide lateral area, according to the general rules mentioned above.

Similar modification is shown in *Staufenia* and *Clydoniceras*.² The latter, a local development³ of the Bathonian *Oppelia*, does not so much "reduce" its suture-line as, rather, take on a specialized type that resembles certain "Pseudoceratites", with an increased number of elements, but less frilling. It is to be noted that the families themselves (Ludwiginae and Oppelidae) are not affected. In *Proplanulites* and *Pictonia*⁴ the reduction is shown in the shortening of the saddles and lobes and the decreased complication

¹ In Zittel-Eastman, *Text-book of Pal.*, 2nd ed., vol. i, p. 673, 1913.

² Menzel, *Zeitschr. Deutsch. Geol. Ges.*, vol. liv, p. 90, 1902.

³ Blake (in *Great Oolite Mollusca*, Mon. Pal. Soc. vol.), from the occurrence of this genus in the southern part only of the Cornbrash outcrop in England, concluded that it was dependent on the presence of the Great Oolite Series below, of whose fauna it was a relic. Compared with the almost universal distribution of the genus *Macrocephalites*, this restriction of *Clydoniceras* is interesting and shows that, like many modern marine organisms, certain Ammonite genera were undoubtedly strictly limited in their horizontal distribution. In aberrant or benthonic types, of course, like the *Oxynoticeras* derivative "*Ægoceras*" *Slateri*, Wright, or *Nipponites*, the local restriction might be expected, more than in active swimmers.

⁴ Tornquist, "Proplanuliten a. d. Westeuropäischen Jura": *Zeit. Deutsch. Geol. Ges.*, vol. xlvi, 1894; also "Die degenerierten Perisphinctiden d. Kimmeridge v. Le Havre": *Abh. Schweiz. Pal. Ges.*, vol. xxiii, 1896.

of their margins. With regard to *Pictonia*, Tornquist¹ stated: "We get the impression that they are Ammonites that have resulted from different groups of normal Ammonites, through general degeneration affecting them under local influences during Kimmeridgian times." It must be repeated here that development or loss of strengthening ornament on the shell would affect the suture-line as much as change of whorl-shape. For e.g. in *Pictonia cymadoce* the ornament may be more "reduced" than the suture-line in one specimen, and in another the suture-line more than the ornament.²

Adaptation to a Nautiloid, or less exclusively swimming mode of life,³ might have taken place in *Frechiella*, which is also often one-sided and which shows the modification of its ancestral *Hildoceras* suture-line in its ontogeny. And the oxycones of *Hudlestonia* and *Stanfenia* were better adapted to an actively swimming existence than their Grammoceratan and Ludwigian ancestors. With Renz and J. von Pia⁴ the writer would be inclined to favour the theory of adaptation, therefore, even if the special mode of adaptation be not quite clear in some cases, rather than speak of decline of vitality or phylogenetic degeneration.

WHOLESALE PHYLETIC "CATAGENESIS".

This applies, of course, also to the modification of the suture-line in the Cretaceous Pseudoceratites, which, however, is on a different scale, and which has been explained as a phenomenon coincident with the approaching end of the whole race of Ammonites. Walther⁵ had stated: "Ammonites, after dominating the seas through three long periods and nearing their end, show in all groups such clear symptoms of abnormal growth, such evident signs of senile degeneration, that their extinction through a kind of senile decay seems to us inevitable." As far as it affected the suture-line, this "degeneration" produced "forms which remind one of Triassic Ceratites and even of certain Palæozoic Goniatites".⁶ Indeed, *Neolobites Vibrayanus* (d'Orbigny) and *Metatissotia Ewaldi* (v. Buch) e.g. had been put into the genus *Ceratites* by d'Orbigny and even into *Goniatites* by Pictet. Just as in the modification of the shell, only certain lineages were affected, however, and these differently and at different horizons. But this going back, as it were, along the line followed in the evolution of the group from Goniatites through Ceratites to Ammonites, however incomplete, fitted into the representation of Ammonite phylogeny as a series of cycles "which

¹ Op. cit., p. 42.

² Ibid., p. 39.

³ Diener ("Lebensweise u. Verbreitung d. Ammoniten": N. Jahrb. Miner., etc., ii, p. 69, 1912) says that *Nautilus* lives chiefly crawling, but can swim well and quickly, and has also been found attached to the bottom, which "shows that its present mode of life is little stable yet". Diener, therefore, does not agree with Dollo ("Les Cephalop. adaptés à la vie nect. second. et à la vie benthique tertiaire": Zool. Jb. Spengel. Festschr., Suppl., xv, 1, p. 111, 1912), who ascribes a primarily benthonic mode of life to *Nautilus*, the "type of the ancient Cephalopod with functional, external shell".

⁴ N. Jahrb. Miner., etc., ii, p. 169, 1913 (in review of Renz).

⁵ *Geschichte der Erde und des Lebens*, 1908, p. 451.

⁶ Haug, *Traité de Géologie*, vol. ii, fasc. ii, p. 1166, 1908-11.

is in direct contradiction to a causal explanation of their development",¹ as it conveys the impression of an inborn racial necessity of a predestined character.

The ceratitic suture is one type of line that may recur in the Ammonoid history, just as the same types of ornament appear repeatedly between the Devonian and the Cretaceous, owing to the limited possibilities of variation in each character. Hyatt² had considered "the multiplication of the principal inflections in Pseudoceratites of the Cretaceous" to be necessitated "in compensation for the suppression of marginals". The pseudoceratitic suture-line also is not by any means always "reduced", so that its function as a means of attachment of the animal to its shell is not impaired. A form like *Indoceras baluchistanense*, Noetling, with 37 lobes and 38 saddles or 75 elements in its suture-line, recalls the acme of specialization among Triassic Ammonites. According to its author, this youngest of all Ammonite genera, the well-formed specimens of which occur abundantly in beds that pass without break or unconformity into the Eocene, shows no geratologous characters.

PERIODIC EVOLUTION AND UNSTABLE ENVIRONMENT.

It might be suggested that in the evolution of the suture-line "periodicity of elaboration" occurs such as is claimed for other features and as is observed in the Cretaceous Asteroidea by Spencer,³ and that after a period of "catagenesis" affecting the Pseudoceratites in general, there was renewed elaboration in *Lybicoceras* or *Indoceras*. There can be no doubt, however, that Pseudoceratites represent a number of independent developments of different normal Ammonites, just as the tendency to attain dissimilarity in form, in response to differences of environment, is shown in many different stocks. This ranges from the Hauterivian *Crioceras* to the Maestrichtian *Bostrychoceras* and culminates (morphologically) in the incredible tangle of *Nipponites*; but their relationship is confined to a similar benthonic mode of life. Strong adaptive radiation, such as is generally shown in the young stages of a stock, occurs repeatedly during Cretaceous, as in previous, times. "Changes of structure and diversity of life" are probably "directly related to the physical conditions of habitat", and the "stability of organic forms is in direct ratio to the stability of the conditions of existence".⁴ As mutation was so continuous during Cretaceous times, the conditions of existence in so far as they concerned the Ammonites cannot have been stable.

EXTINCTION AND ENVIRONMENT. LIME SECRETION.

The writer favours the view that the disappearance of Ammonites was not due to inherent phylogenetic relations and inability to

¹ J. v. Pia, N. Jahrb. Miner., etc., i, p. 169, 1914, in review of Mr. Buckman's *Yorkshire Type Ammonites*.

² In Zittel-Eastman, *Text-book of Pal.*, vol. i, p. 544, 1900.

³ "The Evolution of the Cretaceous Asteroidea": Phil. Trans. Roy. Soc. Lond., ser. B, vol. 204, pp. 156-7, 1913.

⁴ Joel A. Allen, "The Influence of Physical Conditions in the Genesis of Species": *Smithson. Inst. Ann. Rep.*, 1905, p. 401.

modify, but to physical causes. To quote Diener,¹ "A flourishing family like *Lytoceras*, which during the whole of the Cretaceous period produced a number of irregular forms and which, itself, persisted later than these irregular forms, cannot by any means be considered degenerate."

One of the most reduced types, with "goniatitic" suture, is *Flickia simplex*, Pervinquièrè,² which is a morphic equivalent of the Triassic *Lecanites*. Whether this is regarded as a local modification of *Neolobites* or an independent benthonic dwarf development, its Cenomanian age is of no significance; for the writer has seen a specimen in the British Museum (Natural History) with a similar entire suture-line (at a diameter of 12 mm.) from the *Caloceras* bed of the Hettangian that looked like a Palæozoic *Pronorites*. The diminutive size of *Flickia*, of course, suggests unfavourable surroundings; but it appears that in the dwarf faunæ of Morade Ebro³ and other localities the suture-line is little affected.

It is conceivable that thickening of the shell may take place in a series under local influences, i.e. increased lime-secretion, shallowing of the sea, or alteration of the incoming sediment in a more or less confined region. The simplification of the suture-line of *Metoicoceras*⁴ (Turonian *Inoceramus* facies) as compared with that of the Cenomanian *Acanthoceras* may be due to such environmental changes, affecting metabolism generally, and thus the secretion of lime; and this might also apply to the Kimmeridgian *Pictonia* already mentioned, where the suture-line may be more reduced than the ornament in one specimen, and the ornament more than the suture in another.

With regard to the simplification in individual Ammonites referred to above, this follows on a continuous elaboration to often great complexity, and is associated occasionally with approximation of the last few septa, which association alone would account for the simplification of the edge. Or, again, they may be thickened, like the last septum of the recent *Nautilus pompilius* or certain Liassic *Nautili*, and thus make up in the enlarging of the adhering surface for what strength was lost in the simplification. No observations seem to have been made on this point, however.

It will be noted that in *Psiloceras* and other Ammonites the last few suture-lines show what Swinnerton and Trueman in *Dactylioceras* call "simpler and more turgid outlines of the folioles", as

¹ Op. cit., 1912, p. 79. Frech, "Neue Cephalopoden a. d. Buchensteiner, Wengener, and Raibler Schichten d. südl. Bakony": Res. Wiss. Erf. Balatonsees. Pal. Anh. z. Teil i d. Bd. i, p. 72 (quoted by Diener), expresses similar views.

² The local restriction and numerical insignificance of this "goniatitic" form compared with its normal contemporaries and the flourishing *Scaphites* and *Turritiles* shows the incompleteness of the "cycle".

³ A. Wurm, "Beitr. Kenntn. Iberisch-Balearischen Triasprovinz": Verh. Naturhist.-mediz. Ver. Heidelberg, vol. xii, 4, 1913. This fauna is even more reduced than that of St. Cassian, which it resembles.

⁴ M. Leriche, "Sur la présence du genre *Metoicoceras*, Hyatt, dans la Craie du Nord de la France, etc.": Ann. Soc. Géol. Nord, vol. xxxiv, pp. 120-4, 1905.

opposed to their "ageing" character of more intricate wrinkling, assumed to be due to diminished gas-pressure. *Psiloceras* shows not only complex suture-lines with dependent inner portions at first and simpler ones with ascending auxiliaries at the end, but also often asymmetry of the suture-line, and approximation of the last few septa, and these features will be considered in the following parts of this paper.

(To be continued.)

REVIEWS.

I.—ON THE BRACHIOPOD SHALES OF SCANIA.

OM SKÅNES BRACHIOPODSKIFFER. By GUSTAV T. TROEDSSON. Meddelande från Lunds Geologiska Faltklubb, ser. B, Nr. 10, 1918.

THE memoir by Dr. Troedsson on the Brachiopodskiffer of Scania is of importance to students of the Ordovician strata, and must be consulted by anyone who proposes to work at the Ashgillian faunas. These Scanian beds have long been recognized as the general equivalents of the Ashgill Shales of the North of England, which they resemble in respect of lithological characters, fauna, and stratigraphical position.

The memoir is divided into two parts, the first stratigraphical, the second palæontological. In the first part the author gives a historical sketch, which is followed by details of the succession in various localities, and by a comparison of the beds with those of other areas. The second part is concerned with a description of the species.

The fauna consists largely of species which ascend from the *Staurocephalus* beds, but is much poorer in species than are those beds. The author, however, has made a noteworthy addition to the fauna; only five species were known before, whereas he gives a list of forty-six forms.

Although the beds as a whole are equivalent to the Ashgill Shales, it is possible that they contain earlier strata than the lowest part of those shales, for Dr. Troedsson divides them into two sub-zones, the lower (that of *Dalmanites eucentrus*) being distinguished also by the abundance of Ostracods. This is a characteristic feature of a calcareous band with abundant *D. eucentrus* below the Ashgill Shales, which has been bracketed with the underlying *Staurocephalus* beds, and this calcareous band may represent the lowest Brachiopodskiffer, though differing in lithological character. The summit of the Brachiopodskiffer is probably older than the uppermost Ashgill Shales, for the author separates from the former a zone of *Climacograptus scalaris*, which, like the highest Ashgill Shales, is succeeded by the beds of the zone of *Diplograptus acuminatus*. The zone of *C. scalaris* is probably only of local value. *C. normalis* is recorded in England in beds below the Ashgill Shales, and is abundant in the succeeding Valentian rocks, and although it has not yet been found in the shales themselves it must have lived at the time of their formation.