the second phase is propagated as a distortional wave, for, "among material bodies, a solid alone really possesses the rigidity sufficient for the production within it of transverse vibrations and for their maintenance during their propagation."¹ But I have suggested an alternative explanation of the two phases, depending upon the presence of water-gas in the magma, which, from volcanic eruptions, we know to be a constituent.²

The cause usually assigned for the supposed rigidity of the interior is the enormous pressure to which it is exposed. It is held that this would so increase the viscosity as to render it practically solid, but I am not aware that any experimental fact has shown this to be probable; for it is a different question from that of the melting temperature being raised by pressure. We know that in the case of a vapour there is a certain critical temperature, above which no pressure will reconvert it into a liquid. Is it not possible that in the case of a liquid there may be a critical temperature above which no pressure will convert the liquid into a solid? And this may be the case in the earth's interior.

III.—ON THE AFFINITIES OF THE TRIASSIC PLANT *YUCCITES VOGESIACUS*, Schimper & Mougeot.

By E. A. NEWELL ARBER, M.A., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palaeobotany.

IN a paper published in 1907, in the Transactions of the Linnean Society of London,³ I described and figured, under the name *Zamites grandis*, sp. nov., some excellent specimens of detached leaves recently collected by my friend Mr. L. J. Wills, B.A., F.G.S., from the Keuper rocks of Bromsgrove (Worcestershire).

These fossils were regarded as identical with the specimens from the Bunter of the Vosges, first described by Schimper & Mougeot⁴ under the name of *Yuccites vogesiacus*.

In discussing the affinities of this plant I pointed out⁵ that this question had been "a subject of much confusion in the past, and the cause of considerable difficulty at the present". The difficulty lay in the fact that these large, lanceolate, Monocotyledonous-looking leaves, with close, stout, and strictly parallel nerves, were almost invariably detached, and with one possible exception, which, however, was not very conclusive, there was no direct evidence, either from the British or the Continental examples, as to the manner in which they were borne. Consequently direct evidence as to their affinities was lacking.

On the other hand, these leaves presented a very close resemblance to the pinnae of a Zamitean frond except in size, in which respect they were very dissimilar. I concluded, however, that they were the detached pinnae of a Zamitean frond of large size.

¹ Poincaré, *The New Physics*: International Scientific Series, 1907, vol. xc, p. 173.

² Proc. Cambridge Phil. Soc.

³ Arber, Trans. Linn. Soc. London, 1907, ser. II, Bot., vol. vii, pt. vii, p. 109.

⁴ Schimper & Mougeot, Monogr. Plant. foss. Vosges, 1844, p. 42, pl. xxi, figs. 1 and 2.

⁵ Arber, *ibid.*, p. 115.

In this conclusion I was in agreement with Professor Seward, who had recently attributed to the same genus some very similar fossils from the Stonesfield Slate of Oxfordshire, which he described under the name *Zamites megaphyllus* (Phillips).¹ In referring Schimper & Mougeot's specimens from the Bunter, and the examples collected from the English Keuper, to this genus, it was found necessary, for reasons fully explained in my former paper,² to change also the specific name, and the term *Zamites grandis*, sp. nov., was instituted for their reception.

Quite recently, however, Mr. Wills has brought to light a further specimen from Bromsgrove, of great interest as showing the bases of several leaves still attached to an axis. From this example there appears to be no doubt that these fossils were not the detached leaflets of a pinnate frond of Cycadophytean affinity, but *leaves spirally arranged on a stem or shoot*.

This exceptional specimen will be fully described by Mr. Wills in his forthcoming memoir on the Keuper rocks of Bromsgrove. It may suffice to state that it shows a flattened axis, some 8 cm. long, on which portions of some nine leaves are seen spirally arranged, their bases, in three or four instances, being in continuity with the stem or branch.

It is, however, proposed to discuss here the affinities of this fossil, which can no longer be regarded as a member of the Cycadophyta.

In the first place, it is unfortunate that this recent discovery, while of great interest, hardly sheds any definite light on the question of affinity. The fructification of this plant is still unknown, and, until it has been correlated with the leafy shoot, all conclusions must, at the best, be of a provisional nature. As compared with Upper Palæozoic plants, the Bunter and Keuper fossils recall very vividly the leaves of *Cordaite*s. Compter,³ in describing similar, if not identical, specimens from the Lower Keuper of East Thuringia, attributed them to this genus under the name *Cordaite keuperianus*, sp. nov. Zeiller⁴ has supported this conclusion, and has drawn attention to the fact that the occurrence of *Artisia* (*Sternbergia*)-like pith-casts in the Lias, as recorded by Lignier,⁵ lends probability to this view. Further support is also afforded by the reflection that if the Bromsgrove specimens had been obtained from Palæozoic rocks they would undoubtedly have been referred to the genus *Cordaite*s.

On the other hand, it is now apparent that plants of similar habit to those under discussion from the Bunter and Keuper are not uncommon in the Mesozoic rocks. I have recently examined, by the kindness of Professor Sollas, one of the type-specimens⁶ from the Stonesfield Slate of *Zamites megaphyllus* (Phillips), refigured by Professor Seward,⁷ in which some of the leaves are still attached to

¹ See Arber, *ibid.*, p. 117.

² See Arber, *ibid.*, p. 115.

³ Compter, *Zeitsch. Naturwiss.* Leipzig, 1894, vol. lxxvii (ser. v, vol. v), p. 225, pl. iv, fig. 9.

⁴ Zeiller, *Élém. de Paléobotanique*, 1900, p. 213.

⁵ Lignier, *Mém. Soc. Linn. Normandie*, 1895, vol. xviii, p. 135, pl. vii, fig. 13.

⁶ No. ^{MM}₇₄₃ in the Oxford University Museum.

⁷ Seward, *Jurassic Flora*, vol. ii (Brit. Mus. Cat.), 1904, p. 114, text-fig. 11.

the axis. In the light of Mr. Wills' new discovery, I am now of opinion that the mode of attachment here, though not very clearly seen, is probably spiral, and that we are not dealing in this case with a pinnate frond.

Other fossils of a similar type are to be found in the Cretaceous *Krannera mirabilis* of Velenovský and the *Eolirion* (*Elolirion*) *primitivum* of Schenk.¹ The latter strongly recalls the Bromsgrove specimens, and in Schenk's example the leaves are obviously attached spirally to an axis or shoot, with which many of them appear to be in continuity. We have, therefore, a family of plants including the genera *Yuccites*, Schimp. & Mong., *Palæozamia*, Phillips, *Krannera*, Vel., and *Eolirion*, Schenk, existing in both Triassic, Jurassic, and Wealden times, with large Monocotyledonous-like leaves, spirally arranged on the shoot. The question is, are these fossils best regarded as Monocotyledons, or as members of the Cordaitales or Coniferales, or again as a distinct family possibly intermediate between the Cordaitales and Coniferales? For a complete answer we must wait until the fructification is known. At present the balance of probability does not appear to me to lie more in one direction than in another, if we exclude the possible attribution to the Monocotyledons, which, on general grounds, is by far the least probable. It is generally agreed that Monocotyledons did not exist before Lower Cretaceous times, and that the earliest remains of this group come from rocks of slightly more recent age than the British Wealden.

With regard to the possible Cordaitan affinity, there is much to be said in its favour, as Zeiller² has already pointed out. The fact that no *Artisia*-like casts have been collected from the Keuper of Bromsgrove is hardly trustworthy evidence, either for or against the argument. They are already known from a higher horizon, and negative evidence is rarely reliable if unsupported by other data. If the attribution to the Cordaitales proves to be correct, then this group must have been most remarkable in regard to its long persistence in geological time. It occurs in the Lower Carboniferous, if not in the Devonian, and in Upper Carboniferous and Permian times it formed one of the dominant elements of the flora. The argument that, because most of the great dominant Palæozoic groups had either died out, or sunk to the position of subsidiary or insignificant factors in the flora by the time we reach the Rhætic, the Cordaitales were unlikely to have persisted throughout Mesozoic times, is not, however, in itself conclusive, if unsupported. The Leptosporangiate Ferns, for instance, have maintained their place as dominant elements in the flora throughout the Mesozoic and Tertiary periods even to the present day.

Yet in the absence of any knowledge of the fructification I hesitate to accept this view even provisionally. It is possible that the fructifications of these Mesozoic plants may prove to be more nearly related to the Coniferales than to the Cordaitales, or even occupy an intermediate position between the two. The theory that

¹ Schenk, *Palæontogr.*, 1869, vol. xix, Lief. i, p. 20, pl. vii fig. 4.

² Zeiller, *ibid.*, pp. 212-13.

the Coniferales themselves sprang from the Cordaitales, which is widely but not universally accepted as a working hypothesis, would then receive strong support, and the Cordaitan-like leaves would be easily explained. Even in some modern Araucariæ, such as *Agathis* (*Dammara*) *loranthifolia*, Sal., the leaves also to some extent recall those of a modern Monocotyledon, and are not entirely dissimilar to those of *Cordaites*.

I am thus inclined to regard the question of the affinities of this family of Mesozoic plants as an entirely open one until the fructification is discovered. At the same time I think it probable that the fructification will be found eventually to have departed somewhat from the type characteristic of the Cordaitales.

There remains the discussion of the name by which these Bunter and Keuper fossils should be known. Unless we adopt the attribution to *Cordaites* outright, which seems to me to be hardly justifiable, and if we regard the affinities of this plant as still wholly obscure, there seems to be no better course than to fall back on the original name *Yuccites vogesiacus* of Schimper & Mougeot, as a temporary and provisional expedient until more information is available. At present the genus *Yuccites* does not appear to have any established position. The name is of course open to the grave objection that it suggests affinity with the Monocotyledons, to which group, as also in the case of *Eolirion*, it was originally referred. Yet, on the other hand, there do not appear to be any species of *Yuccites* known beyond doubt to belong to the Monocotyledons, and the invention of a new genus, whether implying affinity to the Cordaitales on the one hand or to the Coniferales on the other, does not appear to me to be advisable on the present evidence. I propose, therefore, to retain temporarily the name *Yuccites vogesiacus*, Schimp. & Moug., for these specimens from the Bunter of the Vosges and the Keuper of Bromsgrove.¹

IV.—*LIMULUS WOODWARDI*, SP. NOV., FROM THE LOWER OOLITE OF ENGLAND.

By D. M. S. WATSON, B.Sc., Beyer Fellow of the Victoria University of Manchester.

MY friend Mr. F. H. Gravely during September, 1908, obtained from the ruins of an old wall at Doddington, near Wellingborough in Northamptonshire, the carapace of an Arthropod, the value of

¹ I take this opportunity of correcting two slips which appeared on p. 110, paragraphs 2 and 3, of my previous paper with regard to the horizons on which some of the earlier Cycadophytean fronds occur in the Palæozoic rocks. I am indebted to Professor Zeiller for calling my attention to these errors. The oldest known specimens of *Zamites*, *Plagiozamites*, and *Pterophyllum* should there be stated to be derived from the Stephanian, and not from the Westphalian. Similarly, the beds in the Vosges from which *Plagiozamites* was obtained are of Permian age, and not Westphalian as stated. Professor Zeiller also informs me that the fossil recorded by Zalessky as *Plagiozamites* from Manchuria has proved to be a *Rhacopteris*. Professor Zeiller, in his "Bassin Houiller et Permien de Blanzy et du Creusot", a memoir which I did not see until after my paper had appeared, includes the *Zamites Planchardi* of the Commeny Flora in the genus *Plagiozamites*. Consequently the genus *Zamites* is as yet unknown from the Palæozoic rocks, and it is doubtful if any typical representatives have been described of earlier age than the Rhætic.