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ALAN WESLEY

CONTRIBUTIONS TO THE KNOWLEDGE OF THE FLORA OF THE GREY LIMESTONES OF VENETO: PART I

A REVISION OF THE *FLORA FOSSILIS FORMATIONIS OOLITHICAE* OF DE ZIGNO

(With 6 Plates, 24 Text-figures, and 1 Table)

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PREFACE

This is the first of a series of investigations on the fossil flora of the « grey limestones » (*calcari grigi*) of Northern Italy, based on the rich collection of Baron Achille De Zigno housed in the Museum of the Institute of Geology of the University of Padua.

The major part of this collection was described and illustrated by De Zigno in the two volumes of the *Flora fossilis formationis oolithicae* (1856-85) and in several publications of about the same date. In these two volumes, for which he is best known, De Zigno set out to write a comprehensive description of the fossil flora of rocks that he considered to be of Oolitic age, and there are numerous references to plants from other localities than Italy. It is not generally known, however, that at the time of his death De Zigno was actively preparing a third and final volume, which was to have included descriptions of all the conifers from strata of a similar age together with species collected or determined after the publication of the earlier volumes.

Of the third volume, there exists the unedited manuscript of De Zigno in the Institute of Geology at Padua, and it testifies to the vigour and interest which was maintained by palaeobotanists of the last century, and we must lament the untimely death of De Zigno which prevented his fulfilling what would have been a monumental study.

The task of redescription and completion of the *Flora fossilis*... was commenced by Luigia Grandori, who introduced a revision of the Italian species of the first volume in her *La Flora dei Calcari Grigi del Veneto* (1913). However, she never completed the entire revision, but in an earlier introductory note she had listed the conifers as determined during the preparation of a thesis, and in another contribution there is a description of some seeds.

In this new series of investigations I am planning a complete revision of the Italian species of fossil plants described by De Zigno in the first two volumes of the *Flora fossilis*..., together with a presentation of the still-undescribed forms which are contained in the manuscript of the projected third volume.

Of great importance is the now generally accepted opinion that the fossil flora is of Liassic age and not Oolitic as was formerly thought by De Zigno and other geologists. The assemblage of species gives possibly our only insight into a phase of the history of the world's flora, and my studies by modern methods are revealing that the specimens are even more remarkable than first inspection might suggest.

I wish to acknowledge the financial assistance afforded by the Italian Government in the award of a scholarship which enabled me to spend a period of four months in Italy

during 1952, and without which the studies could never have been commenced. I also wish to thank the University of Leeds for granting leave of absence during the period of tenure of the scholarship, and for financial assistance to continue the studies. To Professor Giambattista DAL PIAZ, Director of the Institute of Geology of the University of Padua, I extend my sincerest and very grateful appreciation for his great kindness in placing the collection and manuscripts of DE ZIGNO at my disposal, as well as all the facilities of that Institute. To Doctor Roberto MALARODA I would like to offer my appreciative thanks for assistance at all times. And finally I must thank numerous British friends, especially Professor T. M. HARRIS, F. R. S., Mr. W. N. EDWARDS, and Doctor J. HEMINGWAY, for their interest, advice and help.

Istituto di Geologia dell'Università di Padova.

Department of Botany, The University of Leeds.

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INTRODUCTION

History of Previous Investigations.

The magnificent fossil flora of the Venetian Alps, in rocks of Jurassic age, was at first only known from a single locality — Rotzo, in the Sette Comuni.

The first fragments were discovered in 1764 by Abbot Agostino del Pozzo, who says in his posthumous *Memorie istoriche dei Sette Comuni vicentini*, published at Vicenza in 1820 - « not less rare and curious is the already mentioned discovery of plants, which are not flattened between layer and layer, as in several other places in Europe, but imprisoned in the middle of the substance of the stone, in which, besides the imprint that one can recognise there, one finds the same herbs with their stems, with leaves, and sometimes also with perfectly conserved flowers, which, using diligence, one can remove. The stone in which they occur is of ash colour, formed of strata not more than a foot thick, and of a calcareous nature. This is quarried on the slope of Mt. Spitz, half a mile above the church of Rotzo. The discovery was made in 1764 on the occasion of covering the walls surrounding the cemetary with such slabs ». I have taken the liberty of translating the words of this and other Italian writers.

Twenty or more years after this discovery, Orazio Maria Pagani, in an oration read before the Accademia Olimpica di Vicenza in 1788, touched upon this subject in speaking of Rotzo, saying - « It is a thing which truly surprises and overcomes the intelligence, the discovery, within very fine compact calcareous rocks, of representations in the form of plants and herbs not known by the most able of botanists ».

In a short note in the *Nuovo Giornale d'Italia*, 1790, Giovanni Arduino says that « at Rotzo one finds, within hard calcareous rocks, beds of plants otherwise only known as indigenous to a very warm climate ». This climatic aspect is also mentioned by G. B. Brocchi in the same publication in 1794.

Abbot Fortis [14], speaking of the more remarkable places of the Sette Comuni, says « I have visited the other more interesting localities; that of Rotzo, where in a bed of bluish compact calcareous rock one finds plants... ».

From 1852 until 1891 De Zigno occupied himself almost entirely with a study of this rich flora. Through diligent and painstaking work in the field he was able to build up a very fine collection of specimens, which formed the basis for the descriptions in a number of publications culminating in the *Flora fossilis formationis oolithicae*, and also to increase the number of localities at which very good specimens could be obtained.

Later workers, usually by reference to the published papers of De Zigno, have chiefly interested themselves only in the botanical side of the flora. However, Grandori [18] sought to bring into better focus the probable geological age of the flora.

Present State of Knowledge of the Flora.

The first catalogue of fossil plants from the « grey limestones » is given by De Zigno [77] who lists twenty-nine species collected from Mt. Spitz at Rotzo, in the Sette Comuni in Vicentino, and at San Bartolomeo in Veronese. In a copy of the paper in the library of the Institute of Geology at Padua, the list carries some corrections in De Zigno's handwriting. Amongst the species mentioned is that of *Otozamites beani* L. & H., but no reference is made to it in any of the later publications.

In 1865 there appeared a description of the new genus *Dichopteris* [86], and in the *Enumeratio filicum fossilium...* [85] diagnoses (without illustrations) are given of thirty -one species of ferns, not all Italian. In *Sopra un nuovo genere di felce fossile* [84], De Zigno dealt fully with the genus *Cycadopteris* and its species.

During this period 1856-68, the first volume of the *Flora fossilis...* appeared, containing the descriptions and illustrations of thirty-two species of fossil plants from the Venetian Alps. Immediately after the publication of this first volume a further note was published with the descriptions of eight more species [87].

The second volume of the *Flora fossilis...* appeared in 1885 containing descriptions and illustrations of thirty-six species. The last published paper dealing with the flora appeared in 1878 under the title of *Sulla distribuzione geologica e geografica delle conifere fossili*. This was to have served as the Introduction to the third and final volume of the *Flora fossilis...* on which he was then working. The manuscript of this is preserved in the Institute of Geology at Padua and bears the last date on which De Zigno was still studying the plants — 25 th. July, 1891 — one year before his death.

This final volume was to have included descriptions of all the fossil species of Oolitic conifers, together with a *Supplementum* in which would have been included the species of ferns and cycad-like plants found after the publication of the first two volumes. Only a few forms are recorded from the Italian deposits, and it is highly probable that De Zigno was still employed in their determination.

From all his descriptions, publications and manuscript notes the definitive list of the flora of the « grey limestones » stands at seventy-six species.

Among the contemporary palaeobotanists of De Zigno, Schimper [56] is to be noted as having given some attention to the Italian species. He reviewed some species at length, and in some cases identified them with other forms. Saporta [52] had earlier described some of the specimens in 1891 and his names were used by De Zigno. Zeiller [75] also studied the peculiar leaf structure of *Cycadopteris* Zig. In general, however, most of De Zigno's contemporaries accepted his determinations.

A more modern attempt at a revision of the identifications of De Zigno was made by Seward [58], who identified some of De Zigno's fossils with ones described earlier from the rich plant-bearing beds of the Middle Jurassic rocks of Yorkshire, England.

A complete revision, based on an examination of the actual specimens, was started by Luigia Grandori in the early part of this century. In her *Dissertazione di laurea in Scienze Naturali* she deals with the species of conifers and cycad-like plants, drawing from the manuscript of the unpublished third volume of the *Flora fossilis...* and revising the species of the published second volume of the same work. An unsuccessful search

has been made for this thesis, and it has only been possible, through the kind permission of the authorities of the University of Padua, to consult a summary of it. This summary (*Riassunto*) bears the title of *Le gimnosperme dei calcari grigi e la loro età geologica* (The gymnosperms of the grey limestones and their geological age).

In an Introduction to her studies published in 1913 [17], the coniferous species are listed together with notes on a number of other forms. A reference is also made to these coniferous genera and species as being characteristic of the Rhaetic and Lias. Another short publication [19] deals with certain seeds which she regarded as very likely belonging to *Lomatopteris* SCHIMPER (*Cycadopteris* ZIG.).

Her most important contribution, however, is *La Flora dei Calcari Grigi del Veneto*, Part I, published at Padua in 1913, in which she introduced a considered and critical revision of the species of the first volume of the *Flora fossilis*...

An independent investigation was made in 1935 by Maria FIORE [12] who recorded the presence of *Wielandiella angustifolia* NATH. in the plant horizon at Roverè di Velo. This was based on a specimen included in a small collection made at that locality.

Geological Age of the Rocks containing the Flora.

The fossil flora of the « grey limestones » is thought to represent a single geological horizon, but in studying it one is inevitably confronted by its age. The age of the fossil flora was formerly regarded as Oolitic by DE ZIGNO and other geologists, but it is now regarded as Liassic, and this opinion I believe is not disputed.

DE ZIGNO was inspired by the intention of establishing parallels between the Italian flora and that of the Yorkshire Inferior Oolite (Bathonian and Bajocian). He erroneously identified some shells with *Terebratula sphaeroidalis* SOW., and *T. ornithocephala* SOW. (Oolitic species), and maintained that the rocks with the flora were of Bathonian age [76; 77; 78].

The opinions of DE ZIGNO were, in great part, accepted by BENECKE [2], but in ZITTEL [89] the horizon of the grey and yellowish plant-bearing limestones of Veneto is not referred to the Oolite, but instead is synchronised with the red marly limestones of Lombardy and Tuscany, which have an ammonitic fauna of Upper Lias (Toarcian) age.

The great complex of so-called « grey limestones » of the Sette Comuni, of Veronese and of Trentino, comprises all three divisions of the Lias - Lower, Middle and Upper (Sinemurian to Toarcian). The plant bed is not continuous, but in large lenticles. In some places there are no traces of its existence, while only a short distance away it may be well represented. In all cases the plant zone occupies the same high position in the « grey limestones », and is always accompanied, as much above as below, by marine beds containing *Terebratula rotzoana* SCHAUR. and *T. renieri* CAT. [DAL PIAZ, 9]. The « grey limestones » are a complex of compact calcareous strata alternating repeatedly with marnose and argillose beds, frequently with beds of coal, and in the upper levels with bands crowded with *Lithiotis* GUMB.

Amongst reasons for now accepting a Liassic age for the flora, is the presence of the Liassic ammonite *Protogrammoceras cornacaldense* TAUSCH von GLOECK. (which is

famous in rocks of Domerian age in Lombardy and Tuscany), as well as *Crassicoeloceras crassum* Y. & B. sp., *Gervilleia buchi* Zig., *Megalodon pumilus* Gumb., and other Liassic faunal types [Vacek, 73; Tausch von Gloeckelsthurn, 69; Dal Piaz, 9; Parona, 44]. *Terebratula rotzoana*, while extending higher in the succession, occurs, with *T. renieri*, *T. punctata* Sow., *Rhynchonella briseis* Gemm. and an associated small *Megalodon* resembling *M. pumilus*, in blackish and grey limestones in the hills of Pallino in Middle Calabria. These rocks are of Liassic age, and with all probability belong to the upper part of the middle stage (Domerian) of the era [Stefano, 63]. *Terebratula rotzoana* and *T. renieri* are undoubtedly Liassic species, and are abundant in the Middle and Upper Lias of the Mediterranean basin [Parona, 44]. The ammonite *Protogrammoceras cornacaldense* is also an indicator of rocks of Middle Lias (Domerian) age in the Mediterranean region.

Taramelli [66; 67; 68] was not willing to accept a Liassic age for the strata containing what he considered to be an assemblage of Oolitic plants. He did not dispute the Liassic age in general of the « grey limestones », but considered that *Terebratula rotzoana* had too wide a vertical range to be of any stratigraphic value. He suggested, however, that if it be true that floras modify themselves more quickly than the associated faunas, then it would be possible to account for this discrepancy of Liassic rocks containing a flora Oolitic in character.

Drawing parallels between the not far distant horizon of Rotzo and a *zona fillitica* in the Feltrine Alps, Dal Piaz [9] finds that the strata are most certainly older than those of San Vigilio with their fauna of Aalenian age, or those of the red ammonitic lombardy limestone with a Toarcian fauna, and accordingly places the plant horizon in the highest part of the Middle Lias (Charmoutian) in the Domerian and in direct contact with the base of the Upper Lias (Toarcian). That is in the zone of *Paltopleuroceras spinatum*, between the zones of *Hildoceras bifrons* and *Amaltheus margaritatus*. Parona [44] and Fabiani & Trevisan [11] also hold this view.

Conditions of Deposition of the Strata.

The extraordinary size of a great number of the specimens, particularly fronds, and the remarkably fine state of preservation of a number of them points to there having been optimum conditions for fossilisation.

From the actual specimens, which are usually widely separated in the rock series, it is obvious that the rate of deposition of the sediments containing them must have been rather rapid. Sedimentation must also have been taking place in localities well away from tidal waters, in very calm surroundings free from wave action and surface disturbances which would have torn or damaged large, entire or pinnatifid leaves.

Parona [44] believes, from the nature of the sediments and the presence of a fauna typical of estuarine and littoral habitats, that conditions were such as to resemble a large shallow gulf into which one or more sluggish rivers were flowing and depositing their fine-grained muds and floating plant débris. Gignoux [15] also regards the « grey limestones » as a littoral type of facies.

Dr. J. Hemingway has very kindly made a petrographic examination of a small specimen of each of the two commonest rock types of the plant horizon — the dark grey

matrix type of Rotzo and the Val d'Assa, and the light buff-coloured matrix type of Pernigotti — and within the limits of the available material makes the following points. Both limestones are very fine-grained, the specimen from Pernigotti being extremely fine (down to 1 μ). This is finer than any comparable rock; the Hydraulic Limestone (Middle Jurassic) of N. E. Yorkshire averages 2 - 3 μ, Solenhofen Limestone (Jurassic) of Southern Bavaria 2 μ, the porcellanous limestones of the Ingleborough district (Lower Carboniferous) 2 - 3 μ. This fineness of grain is obviously an essential factor in the preservation of delicate tissues. In addition both limestones have undergone only a little recrystallisation, which also favours organic preservation. It is likely that they origin-

MIDDLE JURASSIC	Great Oolite	Bathonian		ε	Flora of Upper Deltaic Series - YORKSHIRE		Strata with *Posidonomya alpina* (SETTE COMUNI & APENNINES)
	Inferior Oolite	Bajocian (sensu stricto)		δ	Flora of Middle Deltaic Series - YORKSHIRE		
				γ	Flora of Lower Deltaic Series - YORKSHIRE		
		Aalenian		β		*Megalodon pumilus*,	Strata of S. VIGILIO (*Lioceras opalinum* & *Ludwigia murchisonae*)
				α			
	L I A S	Upper	Toarcian	Whitbian	ζ		
				Yeovilian	ε		
		Middle	(Charmoutian)				
	Part of Lower		Pliensbachian				
		Domerian		δ	Flora of Rotzo and Venetian Alps - ITALY		
		Carixian		γ			
					"grey limestones" with *Terebratula rotzoana*, *T. renieri*, *Megalodon Gervilleia buchi*, *Harpoceras cornacaldense*		
							Red limestones of LOMBARDY with ammonites (*Harpoceras aalense*, *Hildoceras bifrons*, *Phylloceras ultramontanum*, & *Posidonomya bronni*)

TABLE 1. - The geological relationships between the fossil floras of Jurassic rocks in Italy and England. The right-hand column indicates the relative positions of some of the more important Italian fossiliferous strata.

ated from aragonite mud which recrystallised on lithification of the rock without increase in size of crystals.

The petrographic evidence points to an environment like that of the seas around the Bahamas at the present day, where finely crystalline aragonite ($CaCO_3$) is being precipitated from ocean waters in areas of shallow water bordered by mangroves. Against this it must be pointed out that no undoubted evidence of a marine environment exists in the two specimens examined. The thin-walled shells which occur in both may possibly be non-marine. Clearly the environment was stagnant in the case of the dark limestone, which has a low organic content, but the other shows evidence of having been formed under the influence of slight current action.

Localities.

The more important localities at which plants have been collected from the « grey limestones » are as follows:

In Vicentino — Rotzo, Val d'Assa, Mt. Spitz, Roana, Crespadoro.

In Veronese — Roverè di Velo, Pernigotti, San Bortolamio and Mt. Raut near Selva di Progno, Scandolaro, Val Salaorno, Vaio del Paradiso, Valle Zulliani.

Bocca di Trappola, near Revolto, on the border between Veneto and Venezia Tridentina.

Technique.

During the past few decades the development and refinement of certain techniques for the investigation of fossil plant remains has greatly increased our knowledge of the Jurassic floras. In a large number of cases these fossils still retain traces of the original plant material from which the cuticle, itself very resistant to decay, can be prepared in such a manner that microscopic examination reveals details of the pattern of the epidermal cells and stomatal apparatus. By reference to the form of the stomatal apparatus, which is considered to be one of the most conservative parts of a plant, it is thus possible to make identification of a specimen more certain.

A large number of specimens in the De Zigno collection still retain a certain amount of organic material, and cuticle preparations have been made from these whenever possible. In certain instances the preservation has been so poor that all the material has disintegrated completely during the chemical process that is used to obtain preparations for microscopic examination. In such cases it has been necessary to rely on macroscopic characteristics for identification.

The cuticle technique, which involves oxidative treatment with concentrated nitric acid and potassium chlorate followed by extraction with very weak ammonia solution, has been found to work well with most of the specimens studied. Small pieces of the plant material are placed in a cavity-slide with a crystal or two of potassium chlorate and two drops of concentrated nitric acid. After leaving for twelve to twenty-four hours, the material is washed carefully in distilled water and mounted on a plane slide under a coverglass. Dilute ammonia solution is then drawn under the coverglass by means of

filter paper until extraction of all the organic matter (with exception of the cuticle) is completed. The clean and delicate flakes of cuticle are then mounted in Karo syrup.

Karo syrup, diluted to the consistency of dilute glycerine with water or seventy per cent. alcohol, has been found to be an easy medium to handle since no dehydration is necessary before mounting. It has an advantage over glycerine jelly, since it tends to harden still further at higher temperatures and there is thus no possibility of the mounting medium liquifying in a warm climate. Karo syrup is a mixture of dextrose, dextrins and maltose, but the sugars do not crystallise on drying and it sets as firm as Canada Balsam [WESLEY, 74].

DESCRIPTION OF THE FOSSIL REMAINS

CONIFERAE

For convenience the conifers are here divided into forms with thick, spirally arranged leaves the venation of which is not known (Form-genera *Brachyphyllum*, *Pagiophyllum* and *Dactylethrophyllum*), forms with 1-veined leaves (Form-genus *Elatocladus sensu lato*) and forms with several-veined leaves (Form-genus *Podozamites sensu lato*). The first four genera are described in the following pages, while the forms with several-veined leaves will be described and illustrated in the next part of my studies. There is no reason to suppose that any of these groups constitute natural families, and their use is entirely for the sake of convenience.

The reproductive structures will eventually be described separately since there is no proof of organic connection between them and any of the specimens so far examined.

KEY TO THE ITALIAN SPECIES OF *BRACHYPHYLLUM*, *PAGIOPHYLLUM* AND *DACTYLETHROPHYLLUM*

1 Free part of leaf projecting considerably above its own base. 2
Free part of leaf only slightly projecting above its own base, or not at all. 9

2 Free part of leaf distinctly bifacial; stomata not occurring over entire leaf surface. 3
Free part of leaf biconvex or circular in section, without angular margins; stomata occurring over entire leaf surface.
Dactylethrophyllum peristictum.

3 Free part of leaf very long, up to eight times its width, not tapering towards apex; subsidiary cells with papillae.
Pagiophyllum revoltinum.

Free part of leaf not more than twice its width, tapering towards apex; subsidiary cells without prominent papillae. 4

4 Free part of leaf about twice its width. 5

Free part of leaf equalling, or shorter than, its width. 6

5 Epidermal cells elongated; anticlinal walls with many pits.
Pagiophyllum veronense.

Epidermal cells isodiametric; anticlinal walls without pits.
Pagiophyllum robustum.

6 Stomata confined to lower surface of leaf.
Pagiophyllum vicetinum.

Stomata occurring on both surfaces of leaf. 7

7 Margins of leaf entire; epidermal cells without papillae on exposed surface. 8
Margins of leaf scarious or microscopically denticulate; epidermal cells with prominent papillae on exposed surface.
Pagiophyllum magnipapillare.

8 Stomata in rows, never sharing a common subsidiary cell.
Pagiophyllum rotzoanum.

Stomata scattered, not forming rows, often sharing a common subsidiary cell.
Pagiophyllum valdassense.

9 Subsidiary cells with prominent papillae. 10

Subsidiary cells without prominent papillae. 11

10 Shoots slender, about 3 mm. wide; some epidermal cells with very thick anticlinal walls.
Brachyphyllum graciliforme.

Shoots stout, 7 - 10 mm. wide; all epidermal cell walls same width. 12

11 Under surface of leaf strongly bulging, keeled; outer walls of epidermal cells with thick cuticular pads.
Brachyphyllum tropidimorphum.

Under surface of leaf only slightly bulging, not keeled; outer walls of epidermal cells not thickened.
Brachyphyllum kendallianum.

12 Leaf slightly projecting beyond own base; stomata confined to lower surface; epidermal cells 18 μ x 18 μ.
Brachyphyllum praetermissum.

Leaf not projecting beyond own base; stomata all over free surface; epidermal cells 37 μ x 37 μ.
Brachyphyllum appropinquatum.

Form-genus BRACHYPHYLLUM Brongniart.

1823. *Thuites* - Sternberg [64], p. 38.
1828. *Brachyphyllum* - Brongniart [6], p. 109.
1829. *Thuites* Sternberg - Phillips [45], pp. 147 and 153.
1836. *Brachyphyllum* Brongn. - Lindley and Hutton [39], pp. 188 and 219.
1847. *Brachyphyllum* Brongn. - Endlicher [10], p. 308.
1849. *Brachyphyllum* Brongn. - Brongniart [7], p. 69 (ex parte).
1849. *Moreauia* - Pomel [46], p. 350 (ex parte).
1850. *Brachyphyllum* Brongn. - Goeppert [16], p. 241.
1850. *Brachyphyllum* Brongn. - Unger [72], p. 388.
1870. *Brachyphyllum* Brongn. - Schimper [56], p. 334.
1873. *Brachyphyllum* Brongn. - Saporta [50], p. 36.
1884. *Brachyphyllum* Brongn. - Saporta [51], p. 310.
1900. *Brachyphyllum* Brongn. - Seward [58], p. 297.
1919. *Brachyphyllum* Brongn. - Seward [60], p. 315.
1928. *Brachyphyllum* Brongn. - Sahni [48], p. 17.
1947. *Brachyphyllum* Brongn. - Kendall [30], p. 226.

Only the most important discussions of the genus have been referred to in this list. The list is not intended to be complete and many of the discussions do not contribute much now.

Diagnosis: Branching conifer twigs; individual shoots circular in section or terete. Leaves borne spirally, arising from the middle of rhomboidal or hexagonal leaf-base cushions, very thick, broad, typically (including leaf-base cushion) as broad as long; free part of leaf short, not exceeding width of cushion, only slightly overlapping own leaf-base cushion. (Venation not known). Cuticle thick. Stomata occurring over leaf-base cushion and lower surface of leaf, sometimes present on the short upper surface, usually arranged in longitudinal rows converging on leaf apex, sometimes absent from a narrow tract along the midrib; stomatal rows a single stoma wide, not usually sunken, but individual stomata sunken, separated by longitudinal rows of ordinary epidermal cells without stomata; stomata irregularly spaced within the rows, usually separated by epidermal cells, never sharing subsidiary cells. Stomatal apparatus haplocheilic, monocyclic or amphicyclic; subsidiary cells large, all similar, forming a ring of four to six around the guard cells, polar and lateral cells not distinguished; exposed surface of subsidiary cell often forming a cutinised ridge or papilla. Epidermal cells generally rectangular, short, in rows converging on leaf apex, those amongst the stomata less regular; anticlinal walls straight, without pits. Trichomes absent. Hypodermis present, usually cutinised.

Discussion of Genus: The form-genus *Brachyphyllum* was proposed by Brongniart in 1828 for sterile foliage shoots of Jurassic age, which are characterised by pinnate branching in one plane and spirally disposed leaves with a thick lamina of triangular, conical or hexagonal form. A number of species have been described under other generic names, usually without sufficient data. Some knowledge of the internal anatomy, as well as features of the reproductive structures, is available for several species and this points to an araucarian affinity of the genus.

In retaining the name *Brachyphyllum* in preference to *Thuites*, I am adhering to arguments put forward by KENDALL [33]. STERNBERG [64] first used *Thuites* in 1823 and the name should thus have priority over BRONGNIART's later name. However, *Thuites* suggests a resemblance to *Thuja* which has shoots with decussate phyllotaxis. It was in this sense that STERNBERG applied the name to his specimens, but a recent closer examination has now shown the leaves to be spirally disposed [KENDALL, 33]. The figures which PHILLIPS [45] gives of *Thuites expansus?* STERNBERG show in some places decussate and in others spiral leaf arrangement, but this may be a mistake. On cuticle structure STERNBERG's species closely agrees with other species of *Brachyphyllum*, but its cone is different [KENDALL, 33]. It seems, therefore, that the name *Thuites* may eventually be retained for certain specimens, but until we have more knowledge of the reproductive structures, I prefer to follow both SEWARD [60] and KENDALL [30] in maintaining that the name *Brachyphyllum* should be used for shoots which have spirally arranged leaves, rather than to use a name (in this case *Thuites*) which has priority but was used incorrectly in the first place.

In her discussion of the genus *Brachyphyllum*, KENDALL [30] states that « there is no single cuticle character separating the two genera » (i. e. *Brachyphyllum* and *Pagiophyllum*). The two genera differ only in leaf form. In *Brachyphyllum* the free part of the leaf is always short and appressed, not exceeding the width of the leaf-base cushion, whereas in *Pagiophyllum* the free part is much longer and its length always exceeds the width of the leaf-base cushion. However, there is sometimes some slight overlap between extreme forms of each genus and it is not always easy to make a distinction. The separation of the two genera is thus artificial, but most species fall into one or the other group.

I have found that five new species of *Brachyphyllum* exist in the Italian flora, all of them falling closely into the group and characterised by specimens with short, spirally disposed leaves. The species are quite distinct from those described from Jurassic deposits elsewhere in Europe and India [25; 42; 48; 51; 55].

There is a range of leaf-form, from *B. graciliforme* sp. nov. and *B. appropinquatum* sp. nov., which have leaves bulging laterally with little or no development of the upper surface, through *B. kendallianum* sp. nov. and *B. praetermissum* sp. nov., which have the free part of the leaf directed forwards but only slightly overlapping its own leaf-base cushion, to *B. tropidimorphum* sp. nov. with the bulging free part of the leaf directed forwards. The leaves of *B. tropidimorphum* show an approach to some of the short-leaved forms of *Pagiophyllum*, but the upper free surface, though more extensive than in a typical *Brachyphyllum*, is always shorter than the width of the leaf-base cushion.

The cuticles of the five species resemble one another in the absence of trichomes and in having squarish, isodiametric epidermal cells. Only in *B. kendallianum* are stomata absent from a tract along the midrib of the leaf; in the other four species the stomata are distributed over the whole lower epidermis. The arrangement of the stomata varies from rather well-defined rows in *B. tropidimorphum*, through *B. kendallianum* and *B. graciliforme* with less-distinct rows, to *B. praetermissum* and *B. appropinquatum* which have scattered stomata.

The stomatal apparatus is circular in all the species, with the subsidiary cells forming a ring around the guard cells. The exposed surface of each subsidiary cell is evenly thickened in both *B. tropidimorphum* and *B. kendallianum*, but in the other three species there is a well-defined cuticular papilla. The ring of encircling cells is not always complete and is often composed of more cells than there are subsidiary cells. There are usually one or more epidermal cells between adjacent stomata, but *B. tropidimorphum* occasionally has adjacent stomata with the subsidiary cells in contact and without intervening epidermal cells.

KENDALL [30] pointed out that the genus *Brachyphyllum* has an araucarian affinity, showing, however, a combination of characteristics not found in either of the living genera. In its cuticle structure *Brachyphyllum* is comparable with *Agathis* (short epidermal cells with straight walls; stomata tending to form rows; papillae on the subsidiary cells), but in leaf-form the genus is nearest to *Araucaria* (section *Eutacta*), even though the leaves are much longer in the living species. In addition, both *Brachyphyllum* and the Araucariaceae always have their leaves arranged spirally. The new species described here agree well as regards the above points, but unfortunately none of them gives evidence of the venation of the leaves - it is not known if the leaves had more than one vein, a main characteristic of the leaves of the Araucariaceae.

Knowledge of the anatomical features of some species points to their close affinity with the Araucariaceae [HOLLICK & JEFFREY, 28; STOPES & FUJII, 65; SEWARD & BANCROFT, 61], but a resemblance to some of the fossil and recent members of the Taxineae has been reported for *B. spiroxylum* BOSE [BOSE, 3].

Cones attributed to the genus are few, but some have been examined by KENDALL [34], who finds an araucarian affinity for *B. mamillare* BRONGN. On the other hand, the cone of *B. expansum* (STERN.) SEWARD, though incomplete, separates that species completely from the Araucariaceae [33].

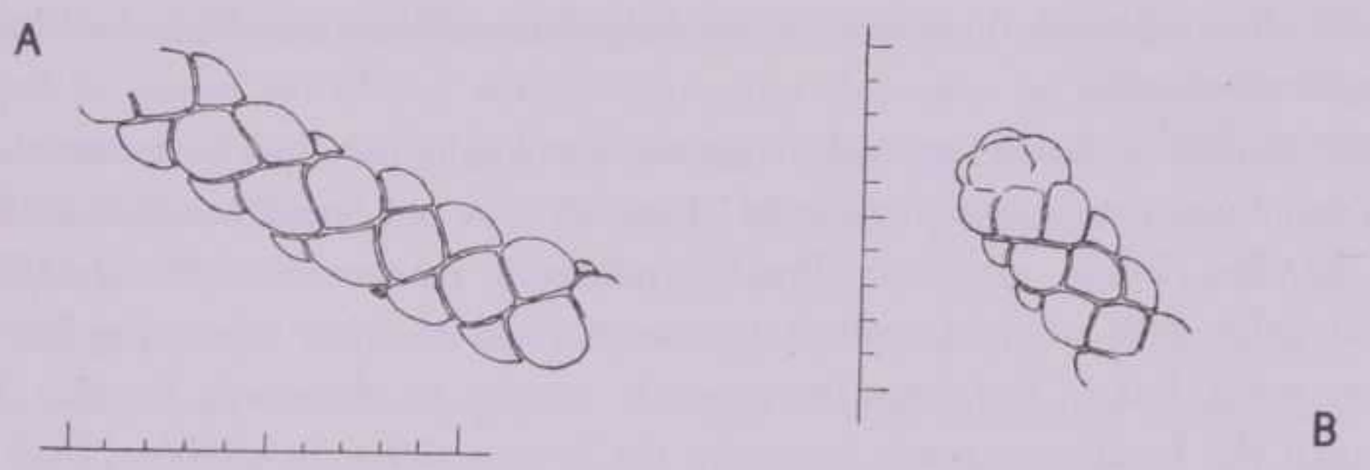
For the present, *Brachyphyllum* must therefore be regarded as an artificial form-genus to be used for vegetative coniferous shoots with short, spirally arranged leaves. Some species probably belong to the Araucariaceae, but others do not.

BRACHYPHYLLUM GRACILIFORME sp. nov.

Plate I, figs. 1-3. · Text-fig. 1 A-B; Text-fig. 2 A-G.

Type-specimen: De Zigno Collection No. 4811.
Localities: Val d'Assa (Type-specimen); Roverè di Velo; Valle Zulliani.
Diagnosis: Branching alternate, in one plane; leafy shoots curved, flexuose, diverging at an angle up to 85°, typically 3.0 mm. wide; ends of shoots very blunt. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base; leaf-base typically 1.5 - 2.3 mm. long and 1.7 - 2.0 mm. broad; leaf thick, bulging, not extending beyond own leaf-base cushion; upper surface much reduced or absent; lower surface convex; apex (when present) rounded. Cuticle rather thick. Stomata arranged more or less in longitudinal rows, separated by 1 - 4 ordinary epidermal cells. Stomatal apparatus slightly sunken in a shallow depression; subsidiary cells forming a ring of 4 - 5,

all similar; polar and lateral cells not distinguished; exposed surface of subsidiary cell evenly thickened, with a broad papilla projecting over guard cells; protected surface evenly thickened, extending back beneath adjacent epidermal cell; aperture of subsidiary -cell pit elongated above guard cells, generally transverse. Encircling cells not specialised, forming an incomplete ring with a slight rim around stomatal apparatus. (Guard



TEXT-FIG. 1. *Brachyphyllum graciliforme* sp. nov.

A. Specimen No. 4780; part of shoot, shown also in Plate I, fig. 2, enlarged to show leaf-form and phyllotaxis. Scale equals 10.0 mm.
B. Specimen No. 4782; apical region of shoot, shown also in Plate I, fig. 3, enlarged. Scale equals 10.0 mm.

cells and orientation of pore not known). Epidermal cells polygonal, isodiametric, typically 28 μ long x 28 μ wide; anticlinal walls of most cells thin, without pits; one or two cell rows with very thick walls (7-8 μ); outer walls thin, flat, not sculptured. Trichomes absent. Hypodermal cells not cutinised.

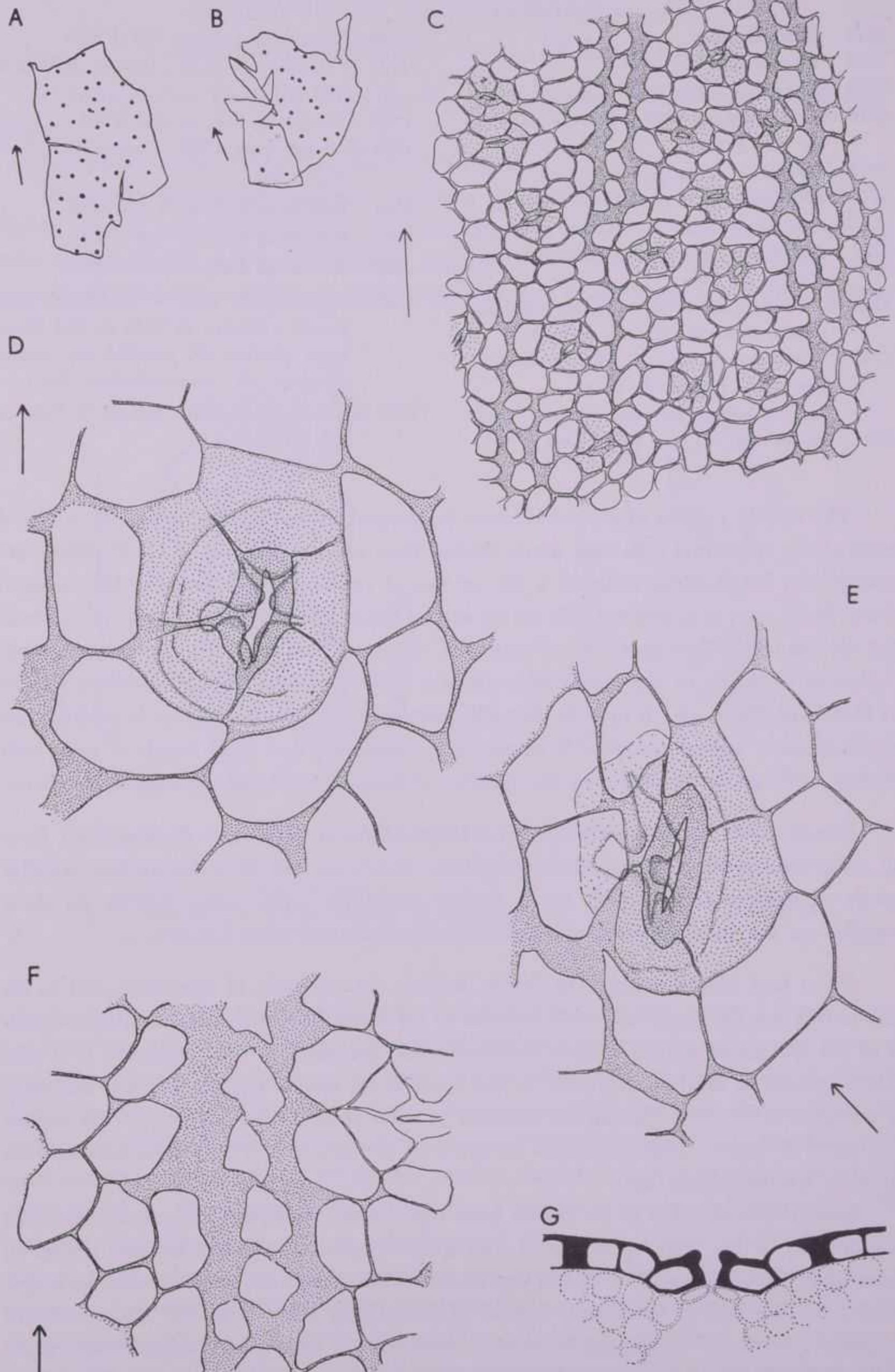
The specific name *graciliforme* is suggested by the slender form of the branches.

Description: The Type-specimen of *Brachyphyllum graciliforme*, on which the complete diagnosis is based, comes from the Val d'Assa, but is unnamed in the catalogue. Unfortunately none of the other specimens with similar external features has cuticle. In all cases the coaly substance disintegrated completely during oxidative treatment. For these, therefore, the identification is less certain.

The slender shoots often diverge at a very great angle, and are always the same diameter as the parent shoots on which they are borne. The ultimate branchlets always have blunt apices and the branching is always in one plane.

TEXT-FIG. 2. *Brachyphyllum graciliforme* sp. nov.

A, B. Cuticle from Type-specimen No. 4811; each dot represents one stoma; slide A. × 29.
C. Cuticle from Type-specimen; slide A. × 160.
D. Cuticle from Type-specimen; one stoma as seen from below; slide A. × 700.
E. Cuticle from Type-specimen; one stoma as seen from below; slide B. × 700.
F. Epidermal cells from cuticle of Type-specimen showing thickened anticlinal walls; slide A. × 400.
G. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
(Each arrow points along the long axis of the specimen figured).


A
B
C
D
E
F
G

On external characteristics, the following are identified as *B. graciliforme*:

4674 - Valle Zuliani
4763 - Roverè di Velo
4764 - Roverè di Velo
4768 & counterpart 4769 - Roverè di Velo or Val d'Assa
4773 - Roverè di Velo or Val d'Assa
4778 - *Brachyphyllum gracile* - BRONGN. - Roverè di Velo
4779 - *Brachyphyllum gracile* - BRONGN. Roverè di Velo
4780 & counterpart 4781 - *Brachyphyllum gracile* BRONGN - Roverè di Velo
4782 & counterpart 4801 - *Brachyphyllum* BRONGN - Roverè di Velo (also labelled *Br. obtusifolium* ZIG.)
4784 - Roverè di Velo or Val d'Assa
4789 - Roverè di Velo or Val d'Assa
4791 & counterpart 4795 - Roverè di Velo or Val d'Assa
4792 - Roverè di Velo or Val d'Assa
4793 & counterpart 4798 - Roverè di Velo or Val d'Assa
4796 - Roverè di Velo or Val d'Assa
4802 - Roverè di Velo or Val d'Assa
4804 - Roverè di Velo or Val d'Assa
4805 & counterpart 4810 - *Brachyphyllum gracile* - Roverè di Velo or Val dAssa (also labelled *Br. gracile?* var. *rotundifolium., B. microphyllum* ZIG.)
4807 & counterpart 4808 - Roverè di Velo or Val d'Assa

The cuticle pattern of *B. graciliforme* is unusual in having the anticlinal walls of some of the epidermal cells very much thicker than others (Text-fig. 2 C, F). They are usually the longitudinal walls of a file or two of epidermal cells between the stomatal rows. These rows of epidermal cells do not extend throughout the entire length of the leaf, but die out where they pass into an area with stomata (Text-fig. 2 C). This extreme variation in thickness of the anticlinal walls is a unique feature among described species of *Brachyphyllum*, and it may be that this peculiarity of *B. graciliforme* is perhaps the result of some wound reaction. It seems likely, however, that these bands of cells with thicker walls probably represent the position of hypodermal bands of supporting tissue.

Comparison: In its cuticle structure *B. graciliforme* is at once distinguished from all other described species of *Brachyphyllum*. None, so far, has shown the peculiar bands of epidermal cells with much thicker anticlinal walls. Some species do show papillae on the subsidiary cells, but differ in a number of other features.

Name and Identification: DE ZIGNO, both in the catalogue of specimens and in his manuscript for the projected third Volume of the *Flora fossilis...*, identified the majority of the specimens as belonging to *Brachyphyllum gracile* BRONGN. GRANDORI [17] also lists *B. gracile* as existing in the flora, and there is no doubt that she too was referring to the same specimens. Among the manuscript notes of DE ZIGNO is a letter from SAPORTA, dated 18 March, 1890, in which he approves the presence of *B. gracile* but remarks upon its Kimmeridgean age.

Undoubted examples of *B. gracile* have never been examined microscopically. An examination of the Type-specimen of that species might reveal characteristics similar to those of *B. graciliforme*, but this is uncertain. I have, therefore, decided to make a new species for the Italian specimens, instead of identifying them with the Kimmeridgean *B. gracile*, because I prefer not to identify specimens of such a very different age, especially when the main diagnostic character, the cuticle, is unknown in one of them.

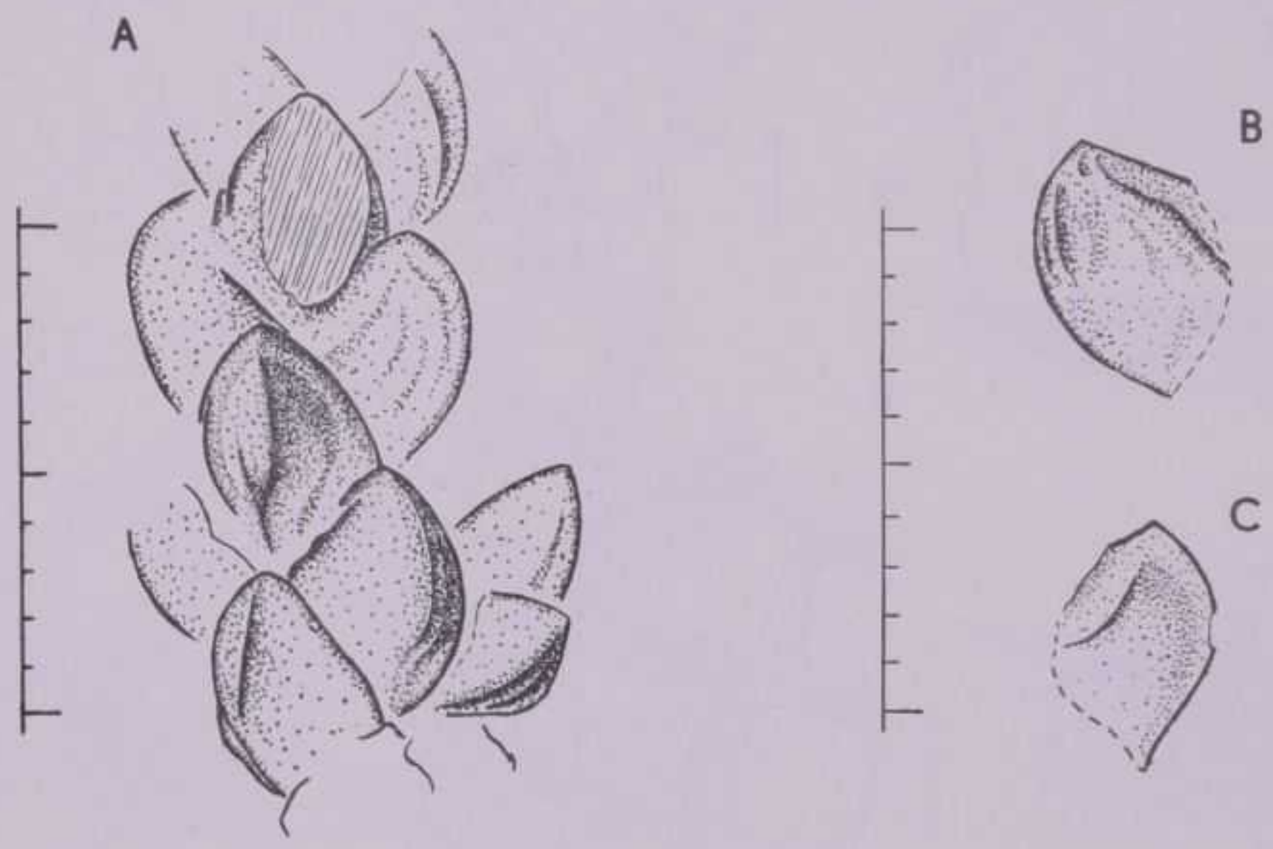
BRACHYPHYLLUM TROPIDIMORPHUM sp. nov.

Plate I, figs. 4-6. - Text-fig. 3 A-C; Text-fig. 4 A-H; Text-fig. 5 A-D.

Type-specimen: De Zigno Collection No. 4731, labelled « *Brachyphyllum Rotzoanum* ».

Localities: Rotzo (Type-specimen); Val d'Assa.

Diagnosis: Branching alternate, probably in one plane; leafy shoots straight or slightly curved, 7.0 - 10.0 mm. wide. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base; leaf-base typically 4.0 - 5.0 mm. long and 3.5 - 4.5 mm. broad; leaf-base cushion partially concealed; leaf thick, bulging, extending a short



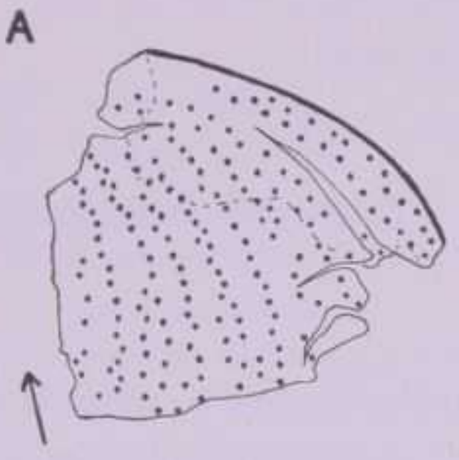
TEXT-FIG. 3. *Brachyphyllum tropidimorphum* sp. nov.

A. Type-specimen No. 4731; part of shoot, shown also in Plate I, fig. 5, enlarged to show leaf-form. Scale equals 10.0 mm.

B, C. Specimen No. 4725; two leaves of the shoot, shown also in Plate I, fig. 4, enlarged; the upper leaf (B) has a rather more extensive upper surface. Scale equals 10.0 mm.

way beyond own leaf-base cushion; upper surface short, convex, up to 2.5 mm. long; lower surface very convex, keeled; lateral margins sharply angular, entire, not spiny or scarious, diverging from apex at an angle of about 80°; apex obtusely pointed. Cuticle thick; structure similar on both surfaces. Stomata on both surfaces, except along the lateral margins, arranged in longitudinal rows on expanded part of leaf, becoming scattered towards leaf-base where completely absent; stomatal rows not sunken, typically separated by 3 - 4 ordinary epidermal cell rows; stomata sometimes adjacent within the row, but never sharing a common subsidiary cell. Stomatal apparatus sunken in a basin-shaped cavity, about 26 μ deep; subsidiary cells wholly sunken, all similar, forming a ring of 4 - 5 around guard cells; polar and lateral cells not distinguished; exposed surface of subsidiary cell raised, united with surface of adjacent subsidiary cells to form a hollow chimney extending up to general epidermal level; protected surface cutinised, bulging slightly over guard cells. Encircling cells unspecialised, at same level as rest of gen-

A



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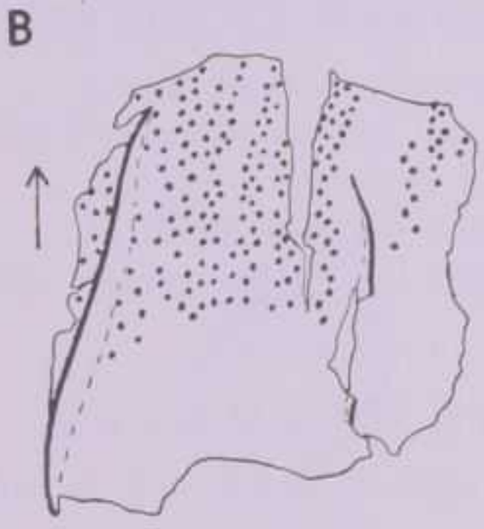

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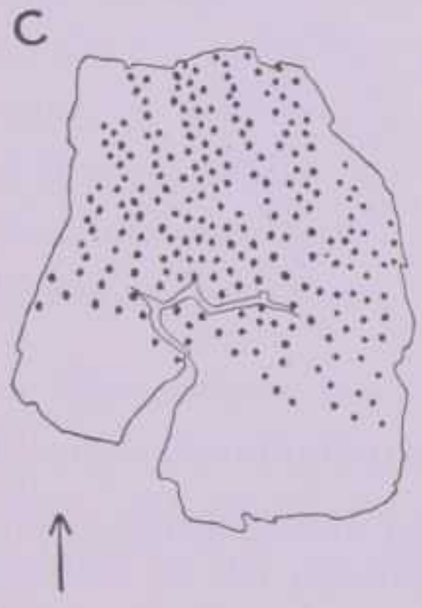

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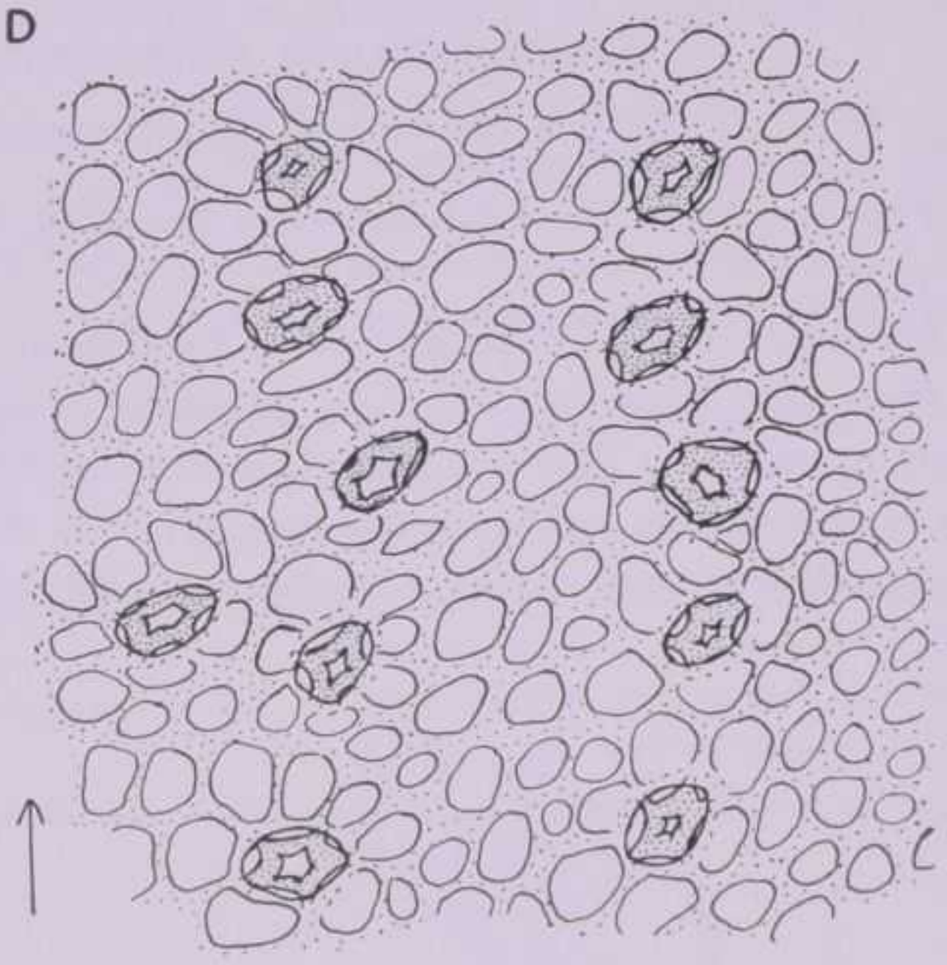
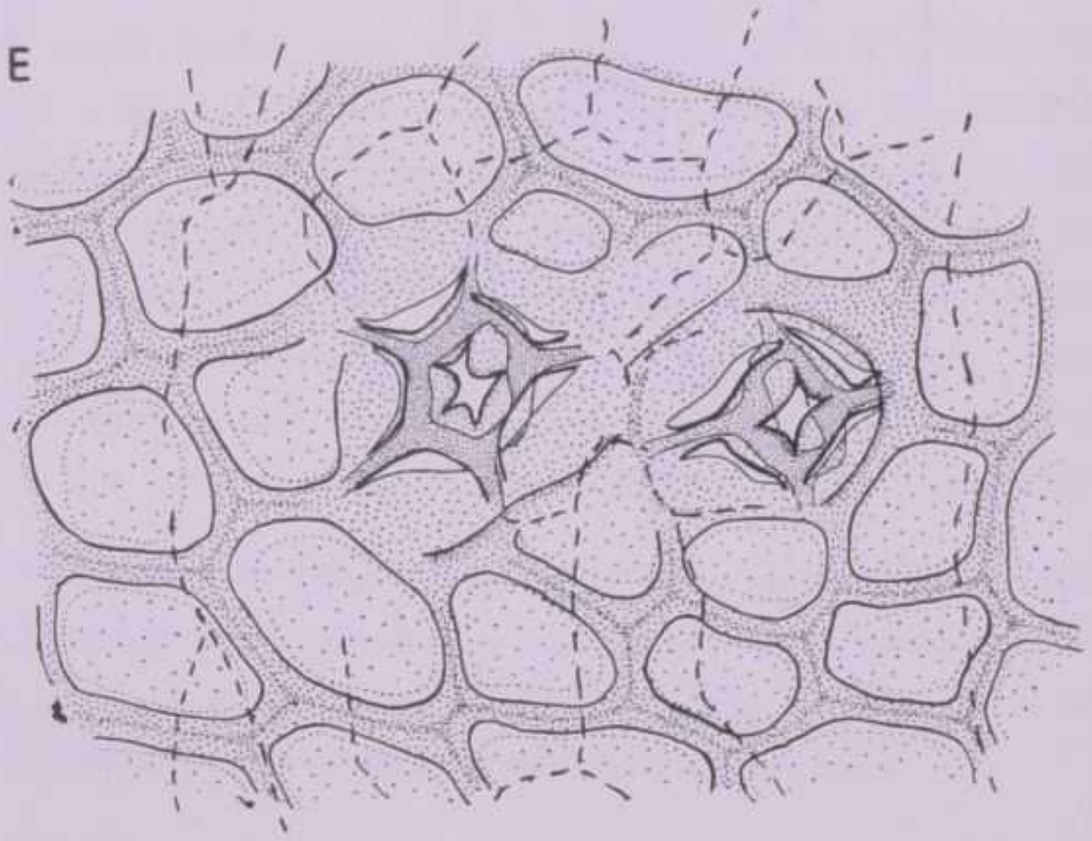
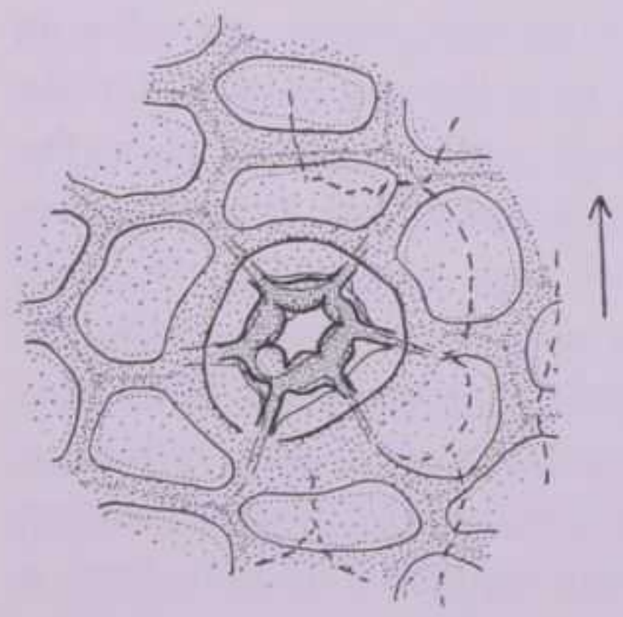


E

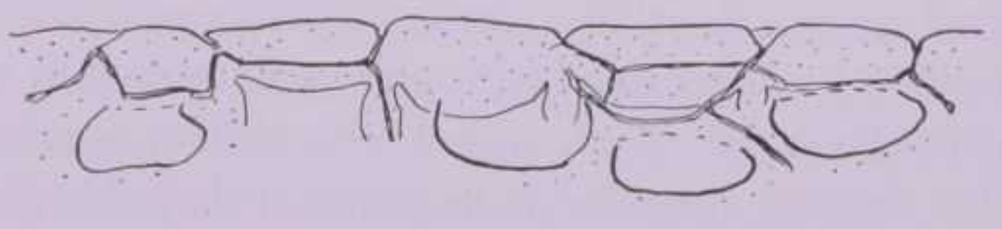


F



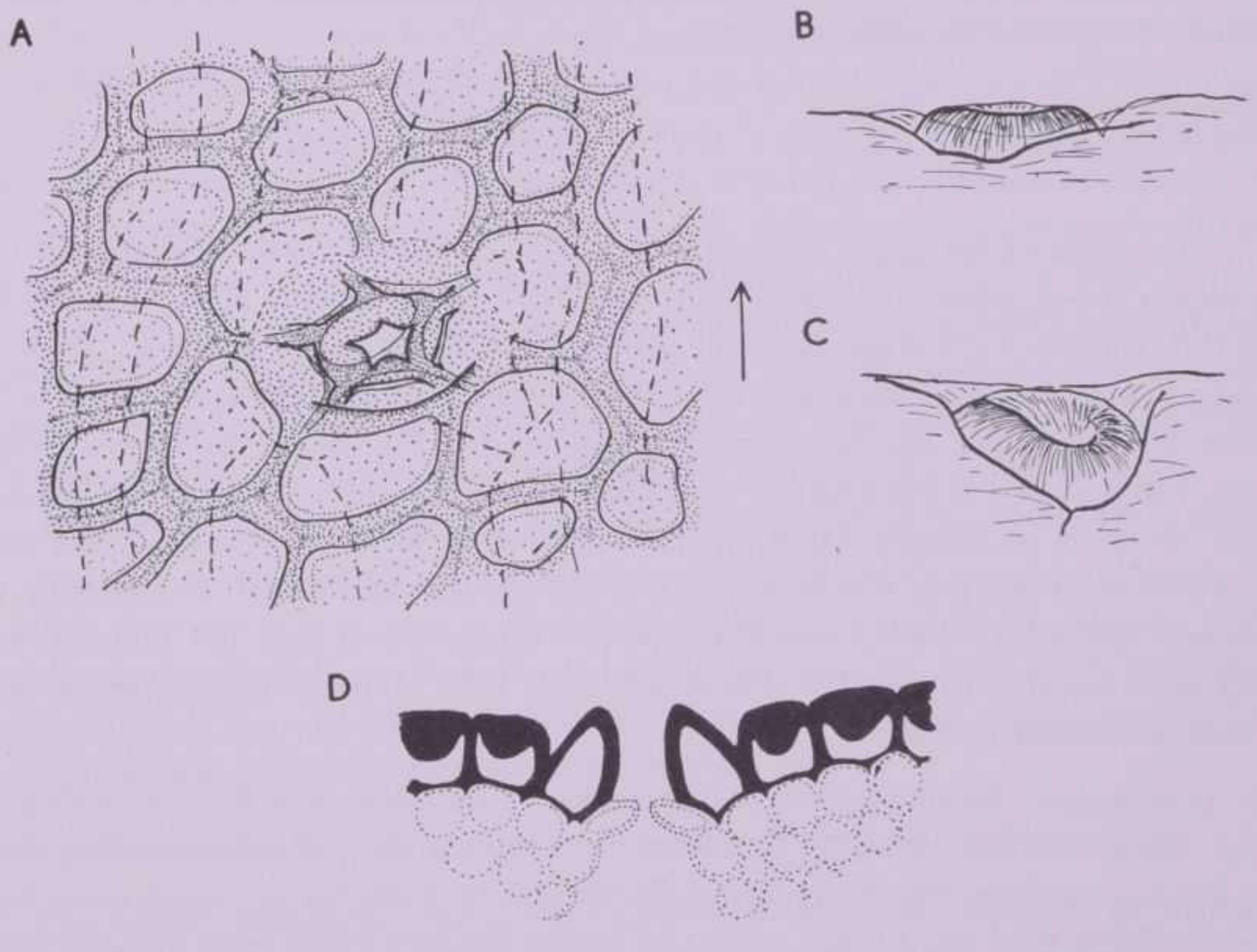
G

H



← TEXT-FIG. 4. *Brachyphyllum tropidimorphum* sp. nov.

A. Cuticle from Type-specimen No. 4731; each dot represents one stoma. × 15.
B, C. Cuticle from specimen No. 4724; each dot represents one stoma. × 15.
D. Cuticle of Type-specimen. × 160.
E. Two adjacent stomata and epidermal cells from cuticle of specimen No. 4724; coarsely stippled areas represent pads of thickening in centre of each epidermal cell; shallow crevices along anticlinal walls shown by close dotting; hypodermal cells indicated by broken lines. × 400.
F. Single stoma and epidermal cells from cuticle of Type-specimen; details of drawing as for E. × 400.
G. Two stomata from cuticle of specimen No. 4743 seen in optical section; slide A. × 400.
H. Fold of cuticle of Type-specimen showing epidermal cells. × 400.
(Each arrow points along the long axis of the specimen figured).



TEXT-FIG. 5. *Brachyphyllum tropidimorphum* sp. nov.

A. Single stoma and epidermal cells from cuticle of Type-specimen; coarsely stippled areas represent pads of thickening in centre of each epidermal cell; shallow crevices along anticlinal walls shown by close dotting; hypodermal cells indicated by broken lines. × 400.
B, C. Cuticle of specimen No. 4743 showing two stomatal apparatuses in side view; slide B. × 400.
D. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
(Arrow points along the long axis of specimen A).

eral epidermis, forming margin of stomatal cavity. (Guard cells and orientation of pore not known). Epidermal cells polygonal, isodiametric, with rounded corners, typically 33 µ long x 33 µ wide; anticlinal walls 5 - 7 µ thick, some with shallow pits, all with a shallow crevice along middle on outside; outer wall with a very large, thickened area forming a pad projecting inwards, occupying most of cell surface. Trichomes absent. Hypodermal cells elongated between stomatal rows, isodiametric near stomata; thinly cutinised.

The specific name *tropidimorphum*, meaning « keel-shaped », refers to the form of the leaves.

Description: In addition to the Type-specimen No. 4731, the following specimens have cuticles showing similar characteristics:

4720 - *Brachyphyllum Rotzoanum* Brongn. - Rotzo
4724 & counterpart 4719 - *Brachyphyllum* - Rotzo
4725 - *Brachyphyllum* - Rotzo
4739 - Scandolara or Val Salorno
4743 - *Brachyphyllum* - Rotzo
4750 - *Brachyphyllum Saportanum* Zic. - Val d'Assa
4771 - Roverè di Velo or Val d'Assa
4862 - Rotzo
5277 - *Brachyphyllum* - Val d'Assa.

The extent of the upper leaf-surface is rather variable. In some specimens it may be almost absent, whereas in others (e. g. No. 4725 shown in Plate I, fig. 4 and Text-fig. 3 B, and No. 4750) it may be about one-third the height of the leaf-base. There is, however, a gradation between both types and I regard the specimens as belonging to the genus *Brachyphyllum*. On the extended part of the leaf the stomata are in well-defined rows, but towards the leaf-base the rows become irregular until, on the actual leaf-base itself, there are no stomata. There are no stomata along the lateral margins, and there is an indication that they may be absent over the median abaxial keel. Occasionally the ordinary epidermal cells between two adjacent stomata are absent, but in such cases each stoma has its own complete ring of subsidiary cells. Adjacent stomata never share a common subsidiary cell.

Comparison: *Brachyphyllum tropidimorphum* comes nearest to *B. scalbiensis* Kendall [Kendall, 30]. It agrees in having the leaf apex often slightly extending above the leaf-base cushion. The leaves have a similar abaxial keel, but are much more bulging. It differs from the English species in having the apex much more obtusely pointed, with the lateral margins diverging at a wider angle. In its cuticle structure *B. tropidimorphum* differs from *B. scalbiensis* in not having the stomatal rows sunken, in its larger isodiametric epidermal cells, which are not rectangular, and in the presence of the chimney-like structure formed by the subsidiary cells.

Some of the specimens might easily be confused with short-leaved forms of *Pagiophyllum peregrinum* (L. & H.) Schenk, but the short leaves of the Italian species are never falcate, and they always show the stomata very crowded in their rows. Also in *B. tropidimorphum* the periclinal walls of the epidermal cells always have a very thick pad of cuticle extending inwards and occupying most of the cell surface. This is not a characteristic of *P. peregrinum*.

BRACHYPHYLLUM KENDALLIANUM sp. nov.

Plate II, figs. 1-3. - Text-fig. 6 A-H.

Type-specimen: De Zigno Collection No. 4751.

Locality: Val d'Assa.

Diagnosis: Branching alternate, in one plane; branches straight or curved, about 7.0 - 10.0 mm. wide. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base; leaf-base typically 3.0 - 5.0 mm. long and 3.0 - 5.0 mm. broad; leaf-base cushion partially concealed; leaf thickish, slightly bulging, extending only a short way beyond own leaf-base cushion; upper surface slightly concave, up to 1.0 mm. long; lower surface convex, bulging slightly, not keeled; lateral margins angular, entire, not spiny or scarious, diverging from the apex at an angle of about 90°; apex bluntly pointed or rounded. Stomata confined to lower surface, arranged in fairly well defined rows, absent from mid region, not reaching to lateral margins; stomatal rows separated by about 3 rows of ordinary epidermal cells. Stomatal apparatus sunken, with a ring of about 5 specialised subsidiary cells; subsidiary cells sunken, all similar; polar and lateral cells not distinguished; exposed surface of subsidiary cell thickened, not forming a cutinised ridge or papilla; protected surfaces thick, forming a more or less cylindrical opening above guard cells. Encircling cells unspecialised, forming an incomplete ring at same level as rest of general epidermis. (Guard cells and orientation of pore not known). Epidermal cells of lower surface rectangular or polygonal, typically 21 μ long x 27 μ wide; cells of upper surface similar, sometimes slightly wider; anticlinal walls of both surfaces 6 μ thick, without pits; outer walls smooth, not sculptured, thinnish on upper surface, thicker and concealing cell-outlines elsewhere. Trichomes absent. Hypodermal cells elongated between stomatal rows; cell-outlines only very thinly cutinised.

The species is named after Miss KENDALL in recognition of her studies of the genus.

Description: *Brachyphyllum kendallianum* is represented by several specimens, all of which show the same general external and microscopic characters. In addition to the Type-specimen, which comes from the Val d'Assa and has the name « *Brachyphyllum Saportanum* » in the catalogue, the following specimens have given cuticle preparations showing the same diagnostic features of the species:

4755 - ? Val d'Assa

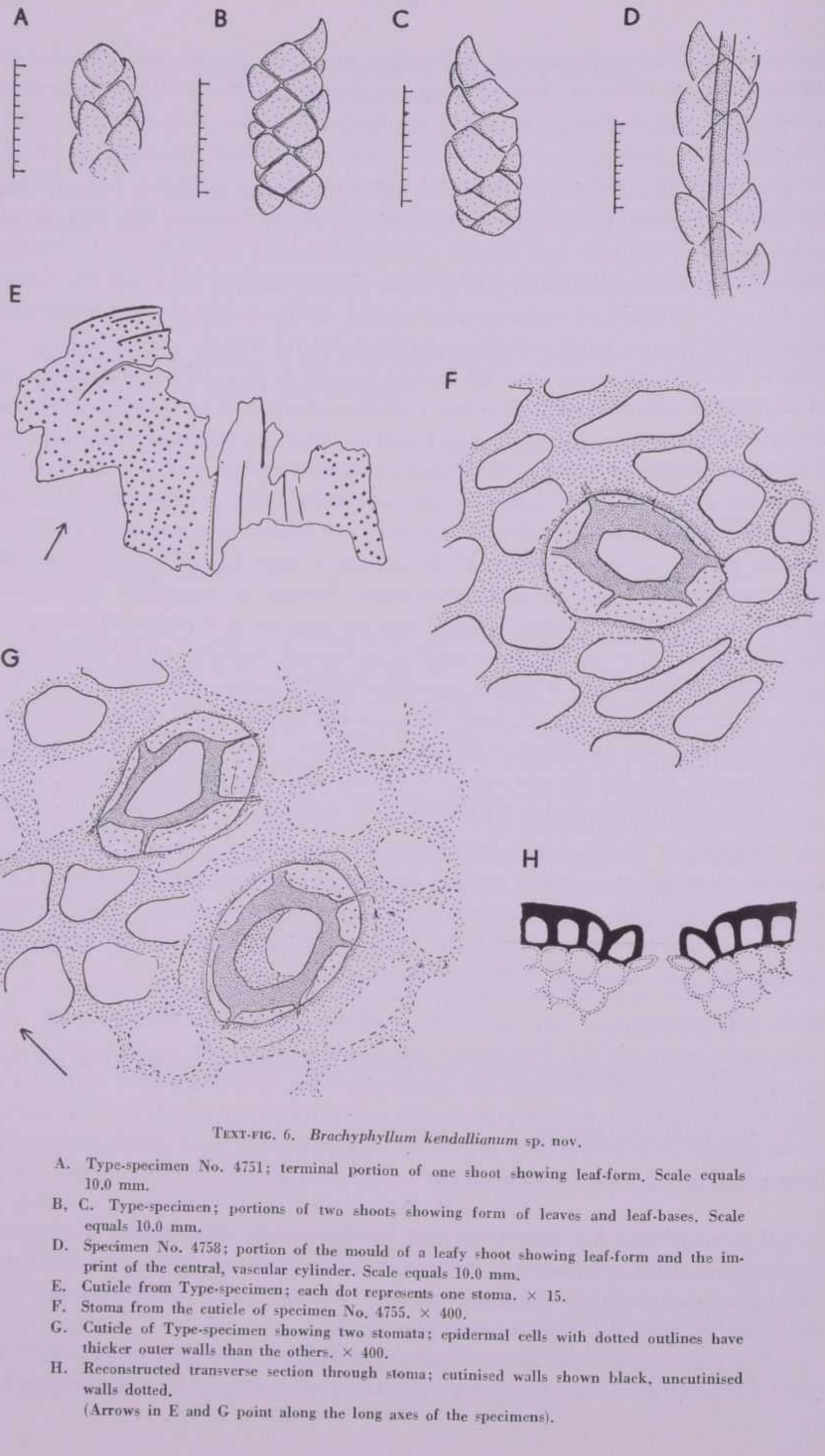
5286 - *Pachyphyllum* - Rotzo

On external morphology alone, the following specimens are considered as belonging to *B. kendallianum*:

4752 - *Brachyphyllum Italicum* ZIC. - Val d'Assa
4753 & counterpart 4758 - ? Val d'Assa
4754 - Val d'Assa
4756 - Val d'Assa
4757 - Val d'Assa

B. kendallianum had very stout shoots for the ultimate branches are always more than 6.0 mm. wide. Some of the specimens are quite large and always show the irregularly alternate branching; the Type - specimen measures about 150.0 mm. long, and specimen No. 4753 is 260.0 mm. long.

It is a typical *Brachyphyllum* with the short bulging leaves scarcely extending beyond their own leaf-bases. The upper leaf-surface, when detached, forms a narrow cre-



TEXT-FIG. 6. *Brachyphyllum kendallianum* sp. nov.

A. Type-specimen No. 4751; terminal portion of one shoot showing leaf-form. Scale equals 10.0 mm.

B, C. Type-specimen; portions of two shoots showing form of leaves and leaf-bases. Scale equals 10.0 mm.

D. Specimen No. 4758; portion of the mould of a leafy shoot showing leaf-form and the imprint of the central, vascular cylinder. Scale equals 10.0 mm.

E. Cuticle from Type-specimen; each dot represents one stoma. × 15.

F. Stoma from the cuticle of specimen No. 4755. × 400.

G. Cuticle of Type-specimen showing two stomata; epidermal cells with dotted outlines have thicker outer walls than the others. × 400.

H. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.

(Arrows in E and G point along the long axes of the specimens).

scent of cuticle. The leaves are very slightly imbricate and partially hide the leaf-bases of those immediately above. All the specimens show the imprint on the rock surface of the woody central cylinder of the plant (Plate II, fig. 1; Text-fig. 6 D). It is also present in No. 5286 as a carbonised region in the centre of the plant substance (Plate II, fig. 3), but chemical treatment has not revealed tracheids or other vascular cells.

The cuticle is not well preserved and it has not always been easy to see the structure of the epidermis properly. The stomata are confined to the lower surface of the leaf, but are absent from an area over the central region. In this area the epidermal cells tend to be slightly more elongated, and have thinner walls. The stomatal apparatus is sunken, but the subsidiary cells have no cuticular papillae on their exposed surfaces.

Comparison: *Brachyphyllum kendallianum* shows some resemblance to both *B. appropinquatum* sp. nov. and *B. praetermissum* sp. nov.. The chief differences are in the structure of the cuticle. Both *B. appropinquatum* and *B. praetermissum* have stomata in which the subsidiary cells always bear strongly developed papillae. These are never present in *B. kendallianum*. In addition, *B. kendallianum* has epidermal cells of a different size and its stomata are always in rows and not scattered as in the other two species. In *B. praetermissum* the stomata occur all over the lower epidermis, but there is a well-defined area in the centre of the leaf of *B. kendallianum* where they are absent. It is not known if such an area occurs on the lower surface of the leaf of *B. appropinquatum*.

B. kendallianum is very like some of the specimens of *B. nepos* Sap. figured by Saporta [51] from the Kimmeridgean of Cirin. Since the cuticle of the French specimens is unknown, I prefer to describe the Italian specimens under a different name.

BRACHYPHYLLUM APPROPINQUATUM sp. nov.

Plate II, fig. 4. - Text-fig. 7; Text-fig. 8 A-G.

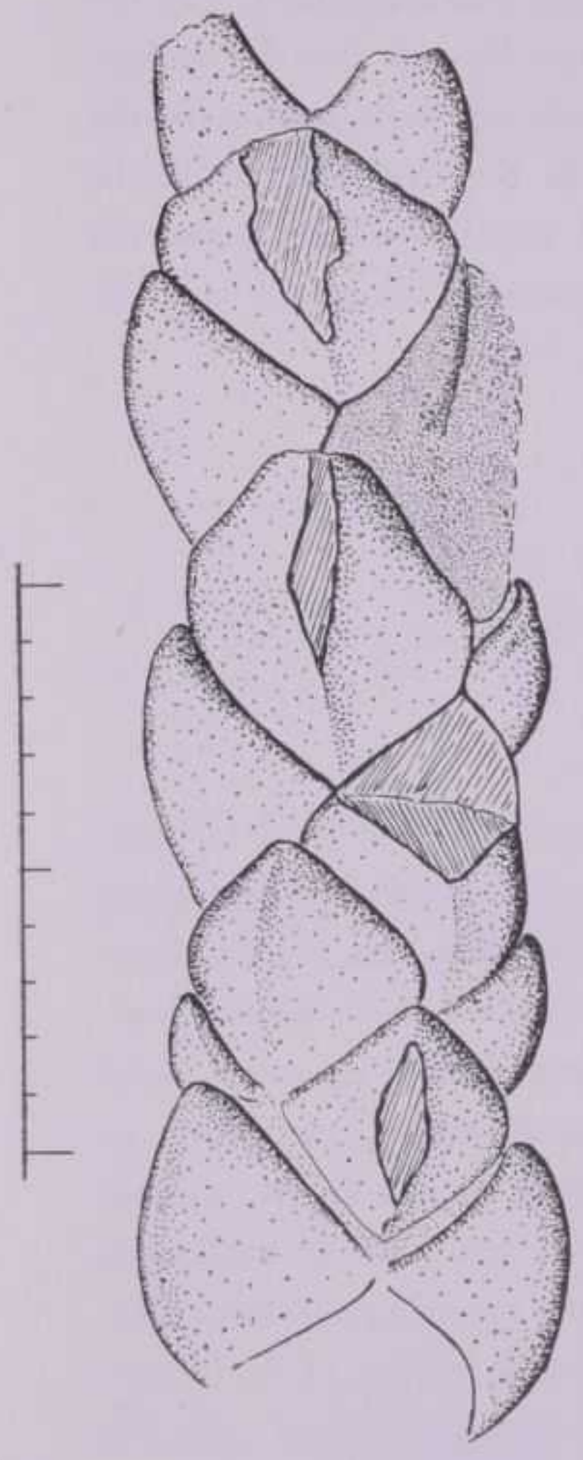
Type-specimen: De Zigno Collection No. 4733.

Localities: Pernigotti? (Type-specimen); Rotzo.

Diagnosis: (Branching not known); leafy shoot curved, not flattened, 7.0 - 10.0 mm. wide. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base; leaf-base typically 5.0 - 6.0 mm. long and 5.0 - 6.0 mm. broad; leaf-base cushion partially concealed; leaf thick and slightly bulging, not extending beyond own leaf-base cushion; upper surface absent or only slightly developed; lower surface convex, slightly keeled; lateral margins (when present) rounded, not angular; apex rounded. Stomata scattered or in indistinct rows, separated by one or more epidermal cells. Stomatal apparatus sunken, with a ring of 4 - 6 specialised subsidiary cells; subsidiary cells sunken, all similar; polar and lateral cells not distinguished; exposed surface of subsidiary cell with a solid peg-like papilla projecting over guard cells; protected surface extending back beneath encircling cell. Encircling cells unspecialised, forming a more or less complete ring at same level as rest of general epidermis, with a slightly thickened rim around opening of stomatal pit. (Guard cells and orientation of pore not known). Epidermal cells forming isodiametric polygons, often nearly square, typically 37 μ long x 37 μ

wide; cells on leaf-base usually shorter; anticlinal walls about 4 μ thick, some with pits; outer walls smooth, not sculptured. Trichomes absent. Hypodermal cells not cutinised.

The specific name is derived from the verb *appropinquare* — meaning « to come near, approach » — and refers to the external from of the plant being similar to some other species.



← Text-fig. 7. *Brachyphyllum appropinquatum* sp. nov.

Part of the Type-specimen No. 4733, shown also in Plate II, fig. 4, enlarged to show leaf-form and phyllotaxis. Scale equals 10,0 mm.

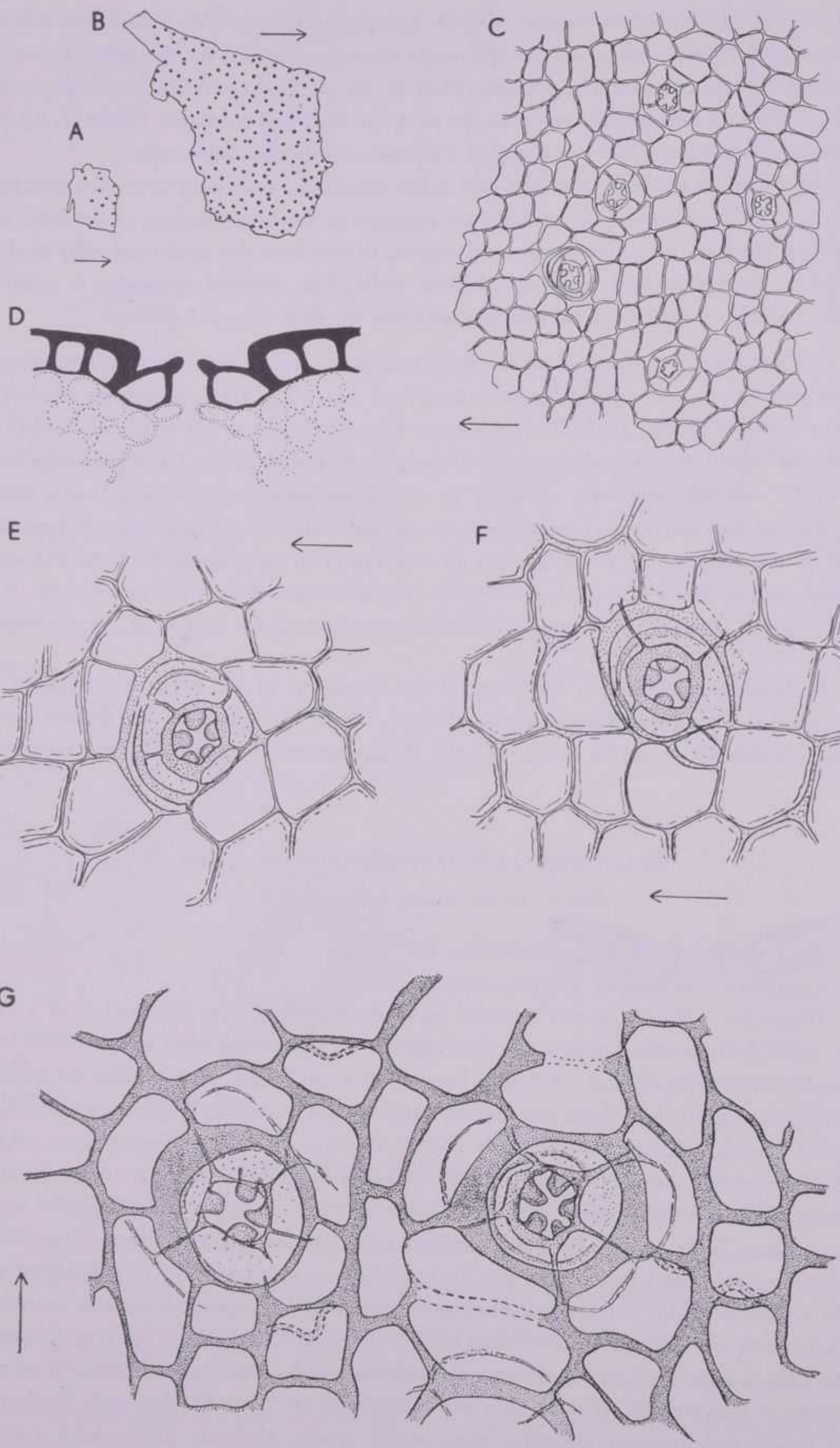
Text-fig. 8. *Brachyphyllum appropinquatum* sp. nov. →

A. Cuticle from Type-specimen No. 4733; each dot represents one stoma. × 15.
B. Cuticle from specimen No. 4880; each dot represents one stoma. × 15.
C. Cuticle of Type-specimen. × 160.
D. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
E, F. Two stomata from Type-specimen; broken lines around epidermal cells represent original thickness of anticlinal walls. × 400.
G. Cuticle from specimen No. 4880 showing two stomata. × 400. (The arrows point along the long axes of the specimens).

Description: This new species is a typical *Brachyphyllum* with its short leaves not extending beyond the leaf-base cushions. It is represented by three specimens: No. 4733, preserved in the buff-coloured limestone of Pernigotti, and Nos. 4880 and 4721, preserved in the dark grey limestone of Rotzo.

The cuticle of No. 4733 is rather thin and fragmentary, but thicker in No. 4880. In No. 4733 the stomata are rather sparsely scattered, which probably represents the distribution towards the leaf-base. In No. 4880 the stomata tend to form rows. The anticlinal walls of the epidermal cells are much thinner in No. 4733 than in No. 4880, but it will be seen from Text-fig. 8 E, F, that they were originally much thicker and that the present appearance is due to partial oxidation of the cuticle.

Comparison: Though *Brachyphyllum appropinquatum* is only represented by three specimens, it seems to have been a species with large shoots. It is not known if the shoots are ultimate branches of the plant.


A
B
C
D
E
F
G

Of the species of *Brachyphyllum*, of which both the external form and cuticle structure are known, *B. appropinquatum* shows the greatest similarity to *B. expansum* (Stern.) Seward [Kendall, 33]. *B. appropinquatum* differs in its larger dimensions and in not having the leaves extending beyond their own leaf-base cushions. Also the margins, when present, are always rounded and not sharp or frilled. In its cuticle structure, particularly the distribution of the stomata, epidermal cell size and shape, and the presence of papillae on the subsidiary cells, *B. appropinquatum* is very like *B. expansum*. It is markedly different in the absence of cutinised hypodermal cells, and in having the protected surfaces of the subsidiary cells extending beneath the encircling cells. In addition, often only the cuticular mass of the subsidiary-cell papillae still remains in stomata where almost all other cutinised surfaces have disappeared. This is not so in *B. expansum* where the papillae may often be absent [Kendall, 30].

BRACHYPHYLLUM PRAETERMISSUM sp. nov.

Plate II, fig. 6. - Text-fig. 9 A-I.

Type-specimen: De Zigno Collection No. 4912.

Locality: « Bocca di Trappola, confine Veneto-Tirolese ».

Diagnosis: (Branching not known); leafy shoot not flattened, about 7.0 - 10.0 mm. wide. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base; leaf-base typically 5.0 - 6.0 mm. long and 5.0 - 6.0 mm. broad; leaf-base cushion partially concealed; leaf thick and slightly bulging, extending a short way beyond own leaf-base cushion; upper surface crescentic, about 3.5 - 4.0 mm. long, slightly concave; lower surface convex and bulging, not keeled; lateral margins angular, entire, not spiny or scarious, diverging from apex at an angle of about 90 - 95°; apex rounded, not pointed. Stomata confined to lower surface, not arranged in well-defined rows, becoming sparse towards leaf-base, where they are absent; stomatal area not quite reaching to lateral margins. Stomatal apparatus sunken in a basin-shaped depression, with a ring of 4 - 6 specialised subsidiary cells; subsidiary cells sunken, all similar; polar and lateral cells not distinguished; exposed surface of subsidiary cell much thickened, with a large solid pa-

Text-fig. 9. *Brachyphyllum praetermissum* sp. nov. →

A. Type-specimen No. 4912; part of the specimen where the plant substance still remains; uppermost leaf shows the extent of the upper surface; lowermost leaf, represented by only an impression in the rock-matrix, shown by close stippling. Scale equals 10.0 mm.

B. Cuticle from Type-specimen; portion of one leaf showing parts of the upper and lower surfaces; stomatiferous (lower) surface shown by close stippling, upper surface not stippled; slide A. × 5.

C. Cuticle from Type-specimen; each dot represents one stoma; slide C. × 15.

D. Cuticle from Type-specimen; epidermal cells with dotted outlines have thicker outer walls than the others; slide B. × 160.

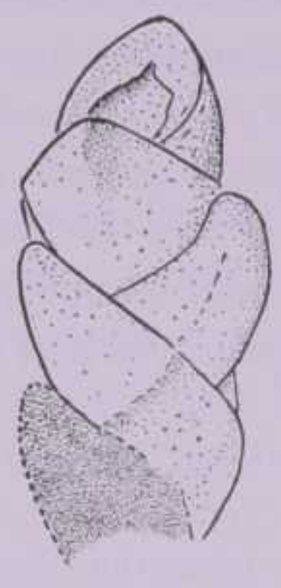
E, F. Cuticle from Type-specimen showing stomata in surface view; slide B. × 400.

G, H. Two stomata from Type-specimen; epidermal cells with broken outlines have thicker outer walls than the others; slide B. × 400.

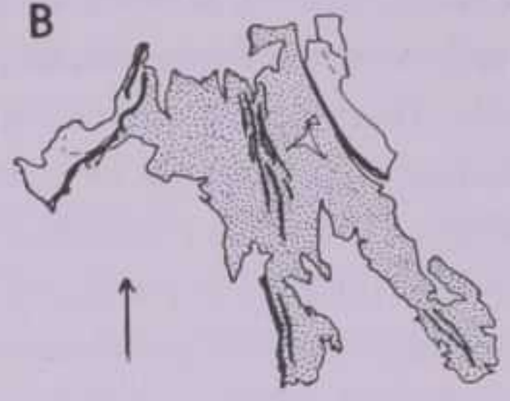
I. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.

(The arrows run parallel with the long axes of the specimens).

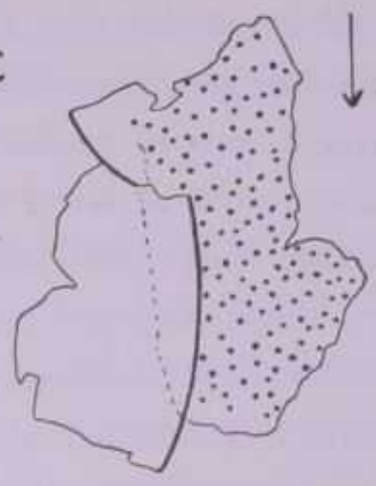
A



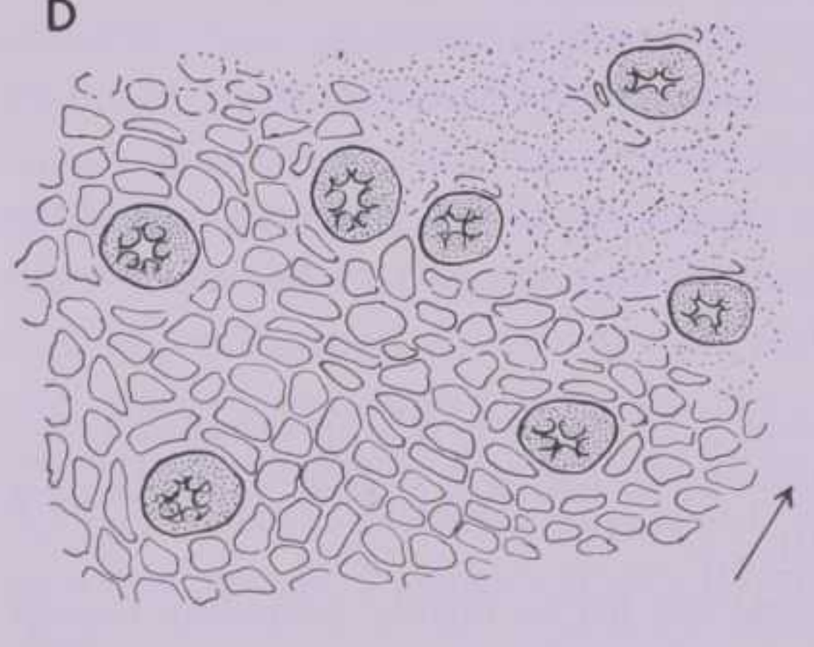
B



C

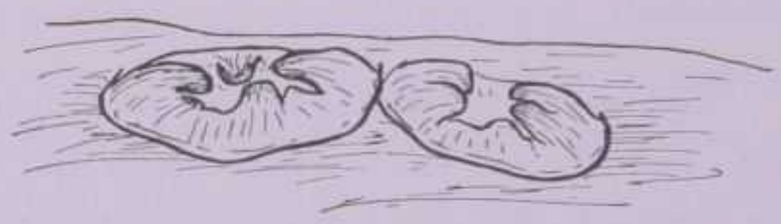


D

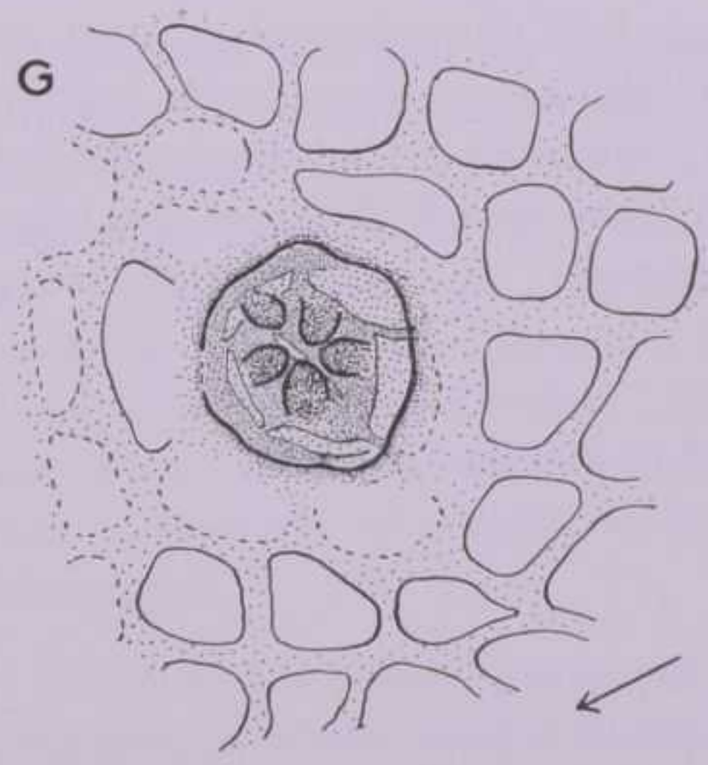


E

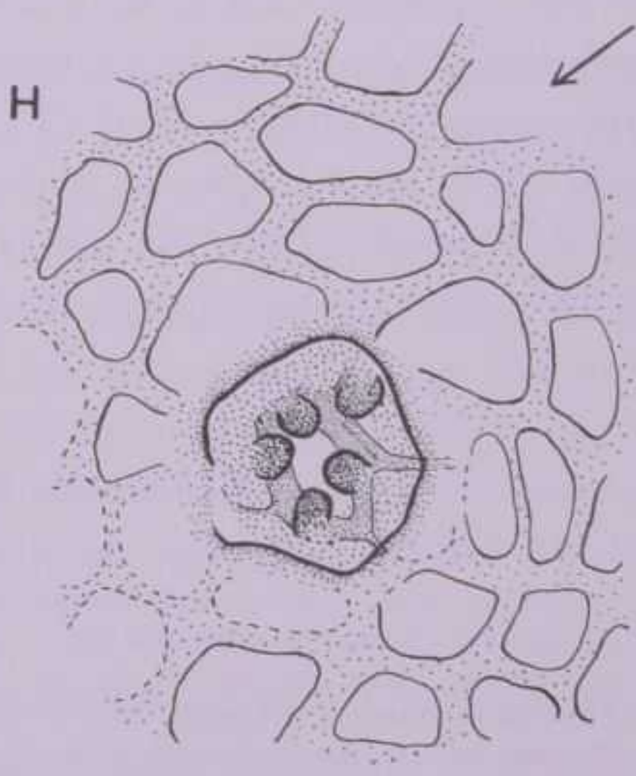
F



G



H



I

pilla projecting over the guard cells; opening of stomatal pit often closed by the subsidiary-cell papillae. Encircling cells unspecialised, forming an incomplete ring at same level as rest of general epidermis. (Guard cells and orientation of pore not known). Epidermal cells of lower surface rectangular, typically 18 μ long x 19 μ wide; cells of upper surface wider, typically 15 μ long x 28 μ wide ; anticlinal walls of both surfaces about 5 μ thick, without pits; outer walls smooth, not sculptured, thinnish on upper surface and towards leaf-base, but thicker and concealing cell-outlines on expanded part of lower surface. Trichomes absent. Hypodermal cells not cutinised.

The specific name is derived from the verb *praetermittere* — « to omit ».

Description: *Brachyphyllum praetermissum* is known only from the Type-specimen. This measures about 70.0 mm. long and has one branch. Only about six leaves with plant substance remain; the remainder of the fossil shows as an impression in the rock matrix. It is a typical *Brachyphyllum*, but is unusual in having the upper leaf-surface slightly concave. In this way, the leaves closely overlap the next above, and their upper surfaces are thus not exposed.

The heavily cutinised outer surfaces are common to all the subsidiary cells of the stomata, but in some of the cuticle preparations they are seen to be less strongly developed.

Comparison: *Brachyphyllum praetermissum* is very close to *B. appropinquatum* sp. nov., but I regard the few differences that there are as sufficient grounds for separating the specimen, described above, as a new species.

It differs from *B. appropinquatum* in having the leaves slightly projecting beyond their own leaf-bases, and in the presence of a crescentic-shaped concave upper surface to each leaf. It also differs in the absence of stomata from this upper surface (in *B. appropinquatum* the stomata occur all over the leaf), and in the smaller size of its epidermal cells. Both species agree in having cutinised papillae on the subsidiary cells, but those of *B. praetermissum* are always very much more strongly developed and often completely close the openings of the stomatal chambers.

Formi-genus PAGIOPHYLLUM Heer.

1833. *Araucaria* Juss. - Lindley and Hutton [38], p. 19.
1838. *Araucarites* - Presl. in Sternberg [64], p. 204 (ex parte).
1845. *Araucarites* Presl. - Unger [71], p. 201 (ex parte).
1847. *Araucarites* Presl. - Endlicher [10], p. 201 (ex parte).
1849. *Brachyphyllum* - Brongniart [7], p. 104 (ex parte).
1849. *Moreauia* - Pomel [46], p. 350 (ex parte).
1849. *Pachyphyllum* - Pomel [46], p. 352 (non Hunboldt, Bonpland and Kurth).
1850. *Araucarites* Presl. - Unger [72], p. 381.
1850. *Araucarites* Presl. - Goeppert [16], p. 231.
1870. *Pachyphyllum* Pom. - Schimper [56], p. 249.
1873. *Pachyphyllum* Pom. - Saporta [50], p. 39.
1881. *Pagiophyllum* - Heer [27], p. 11.
1884. *Pachyphyllum* Pom. - Saporta [51], p. 373.
1900. *Pagiophyllum* Heer - Seward [58], p. 290.
1919. *Pagiophyllum* Heer - Seward [60], p. 274.
1948. *Pagiophyllum* Heer - Kendall [31], p. 74.

This list only includes some of the more important discussions of plants referred to the genus. It is not intended to be complete, and some of the discussions contribute little now.

Diagnosis: Branching conifer twigs; individual shoots circular in section or terete. Leaves borne spirally, triangular, thick with broad bases, arising from decurrent leaf-base cushions; free part of leaf at least as long as broad, typically much longer, always projecting above own leaf-base cushion; lower surface very convex; upper surface concave or convex; lateral margins entire, angled; apex acute. (Venation not known). Stomata always occurring on lower surface of leaf, usually on upper surface also, widespread, tending to form longitudinal rows separated by rows of ordinary epidermal cells frequently with irregularly spaced stomata, sometimes absent from a tract along the middle of the lower surface; stomatal rows a single stoma wide, not sunken, but individual stomata sunken, becoming irregular on leaf-base cushion; adjacent stomata in a row usually separated by ordinary epidermal cells, but encircling cells occasionally in contact. Stomatal apparatus haplocheilic, usually amphicyclic; subsidiary cells fairly small, all similar, forming a ring of three to six around the guard cells, polar and lateral cells not distinguished; exposed surface of subsidiary cell often bulging to form a cutinised ridge of papilla; wall between subsidiary and encircling cell strongly cutinised. Epidermal cells generally rectangular, elongated, those amongst the stomata same width, square or transversely elongated, all becoming short, with thicker anticlinal walls, near bottom of leaf-base cushion; anticlinal walls broad, straight, often with pits; outer periclinal walls sometimes striated. Trichomes absent. Hypodermis present, cells elongated, usually cutinised.

Discussion of Genus: The form-genus *Pagiophyllum* was instituted by Heer in 1881 to replace *Pachyphyllum*, which had been first used by Pomel [46] for a section of his genus *Moreauia*, because *Pachyphyllum* had been applied to a member of the Family Orchidaceae. Some shoots, which should have been referred to species of *Pagiophyllum*, have been called *Araucarites*. *Araucarites* is, however, a genus of cones, not of shoots.

As far as I know, no anatomical information has been obtained from any of the species which have been described, and such detailed and systematic knowledge that we have of the genus, has been provided by a study of the cuticle structure and some cones, particularly of English species, for which an araucarian affinity has been demonstrated.

Pagiophyllum includes plants with spirally disposed leaves resembling those of the recent genus *Araucaria* (section *Eutacta*). Each leaf is usually thick, with the free upper surface exceeding the width of the leaf-base cushion. *Pagiophyllum* is very much like *Brachyphyllum*, and the length of the leaf in relation to its breadth is the main distinguishing feature between the two genera. Sometimes, however, this distinction is not perfect and there may be some slight overlap between extreme forms of the genera. The names *Pagiophyllum* and *Brachyphyllum* are used for the sake of convenience and there is every likelihood that both include shoots which would be placed in other genera if the reproductive structures were known.

In my determinations of the Italian species, I have followed KENDALL [31] and used her extended diagnosis of the genus. The cuticle of all the species conforms to the same general pattern and agrees closely with that described for other species. There is close agreement between *Pagiophyllum* and *Brachyphyllum* as KENDALL [31] has pointed out, but the new species described here fall fairly clearly into the former genus. All of them are quite distinct from those of the British Jurassic flora, and I have not been able to identify any of them with forms from other European and Indian strata [8; 25; 27; 37; 42; 48; 51; 55].

Of the seven species described, *P. veronense* sp. nov., *P. robustum* sp. nov., *P. rotzoanum* (MASSALONGO) n. comb., and *P. valdassense* sp. nov. have the typical leaf form. *P. revoltinum* sp. nov. has unusually long leaves which do not taper towards the apex, while *P. vicetinum* sp. nov. and *P. magnipapillare* sp. nov. have comparatively shorter leaves and approach the *Brachyphyllum* type. All agree in having thick leaves, which point forwards. The margins of the leaves are somewhat angular in all the species, usually entire and not spiny or scarious, but in *P. magnipapillare* the margin is microscopically denticulate.

The stomata are arranged more or less in rows a single stoma wide, and in some species (*P. rotzoanum* and *P. valdassense*) they avoid a tract over the median keel. Only in *P. vicetinum*, as in the English *P. maculosum* KENDALL, are stomata completely absent from the upper surface — a character of the recent genus *Agathis*. The stomatal apparatus of all the species is circular and the sunken guard cells are surrounded by a ring of specialised subsidiary cells which are all similar. Adjacent stomata are usually separated by one or more epidermal cells, but *P. valdassense* is unusual in having some stomata sharing a common subsidiary cell.

The epidermal cells between the stomatal rows are usually somewhat elongated, very much so in *P. veronense* and *P. revoltinum*, but less so in the other species. This is a characteristic of the living *Araucaria*, but all the species (including those from English rocks) have, in addition, features which are characteristic of *Agathis* - epidermal cells with straight walls and the surfaces of the subsidiary cells developed as cutinised ridges or papillae. The outer surfaces of the epidermal cells are usually flat, but *P. magnipapillare* is peculiar in possessing large cuticular papillae on the outer walls which may be so big as to overlap adjacent cells. A similar feature has only been recorded before for *Brachyphyllum scotti* KENDALL [32].

Unfortunately none of the new species gives any information about the venation of the leaves and it is not known if one or more veins were present in each leaf.

The cones of *Pagiophyllum* are not well-known, but KENDALL [35] has attributed some araucarian cone-scales, called *Araucarites estonensis* KENDALL, to *P. connivens* KENDALL, which enhances the possible araucarian affinity of the genus. CARPENTIER [8] has found typical *Pagiophyllum* shoots with cones to which he has given the name *Elatides peregrina* (L. & H.). However, this name has been applied to cones which are superficially like *Elatides* in HEER'S sense and refers to their external form only. A microscopic examination is necessary before they can be compared with specimens described by HARRIS [22]. As HEER described the genus, some of the specimens could still be araucarian [26].

The vegetative characteristics of shoots referred to *Pagiophyllum* suggests that the genus should be classified with the Araucariaceae. There is some evidence that one species has araucarian cone-scales, but there is little to show that the genus is natural. The position is thus the same as for *Brachyphyllum*.

PAGIOPHYLLUM VICETINUM sp. nov.

Plate II, fig. 5. - Text-fig. 10 A-F; Text-fig. 11 A-F.

Type-specimen: De Zigno Collection No. 5279.

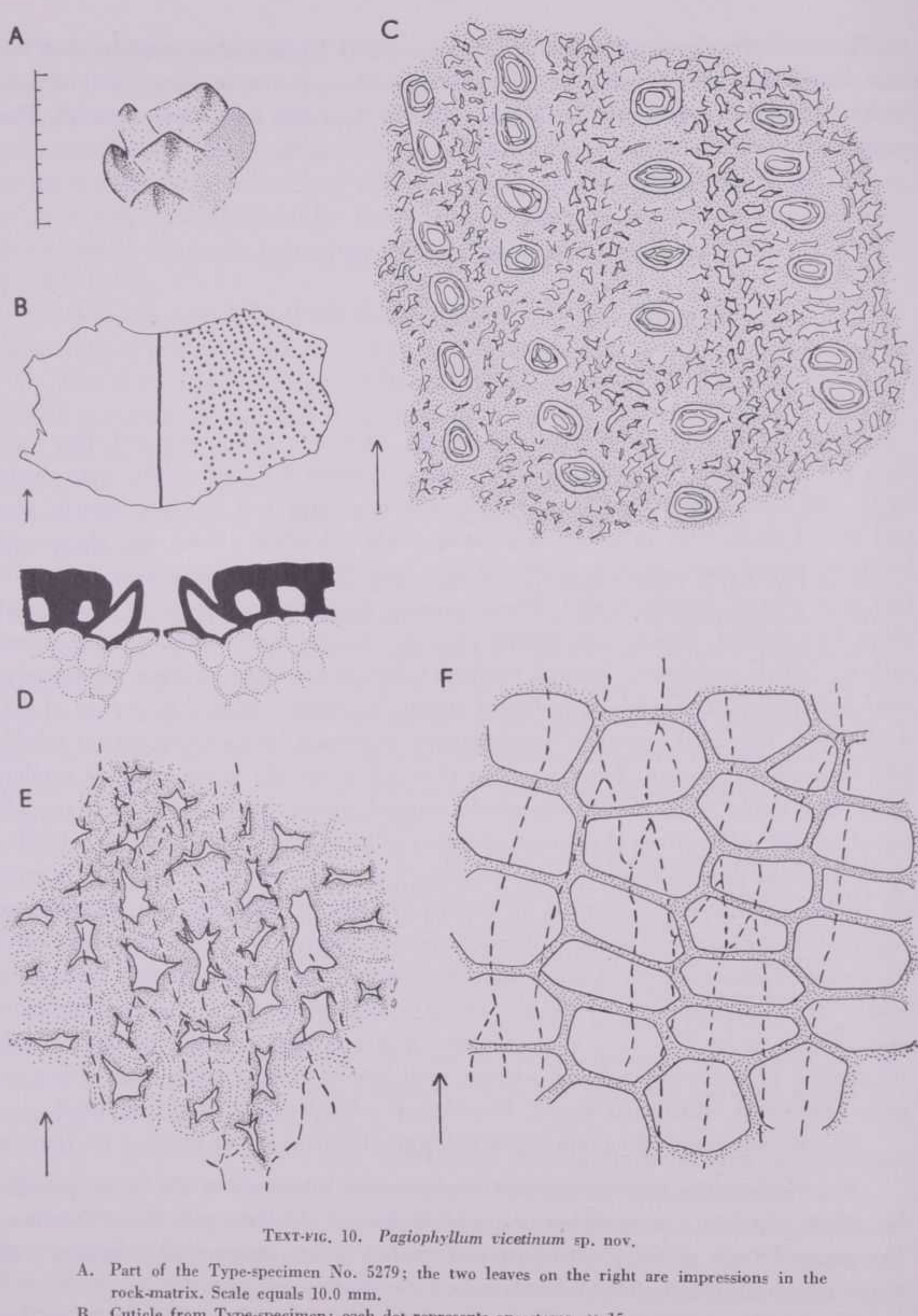
Locality: Rotzo.

Diagnosis: Branching alternate; leafy shoot 10.0 mm. wide; axis including leaf-bases 6.0 mm. wide. Leaves arranged in a spiral of about 3/8; leaf arising from rhomboidal leaf-base cushion; leaf-base typically 3.5 mm. long and 5.0 mm. broad; free part of leaf short, with an upcurved blunt tip, only extending a short way above own leaf-base; upper free surface typically 1.5 mm. long; leaf biconvex in section; lower surface very convex, broadly keeled; lateral margins diverging from apex at an angle of about 95°, angular, entire; apex bluntly pointed; stomatal rows conspicuous on lower surface. Cuticle very thick. Stomata confined to longitudinal rows on lower surface only; rows not sunken, not reaching to lateral margin, typically separated by 3 rows of epidermal cells. Stomatal apparatus deeply sunken to form a basin-shaped cavity; subsidiary cells wholly sunken, forming a ring of 4 - 5 above the guard cells, all similar; polar and lateral cells not distinguished; exposed surface of subsidiary cell strongly raised, united with surface of adjacent subsidiary cells to form a hollow chimney extending upwards to the general surface; protected surface cutinised, extending back under general epidermis; margins of stomatal pit formed by adjacent epidermal cells (possibly encircling cells). Guard-cell surfaces thinly cutinised; aperture variably orientated, often transverse. Epidermal cells of upper surface polygonal, slightly broader than long, 20 μ long x 34 μ wide; anticlinal walls 4 μ thick, without pits; cells of lower surface more isodiametric, about 20 - 25 μ long and wide, with very thick anticlinal walls (up to 20 μ) tending to be convoluted and without pits; lumina of cells small, often almost entirely obliterated. Trichomes absent. Hypodermal cells elongated, thinly cutinised.

The specific name *vicetinum* is derived from the name of the Province of Vicenza.

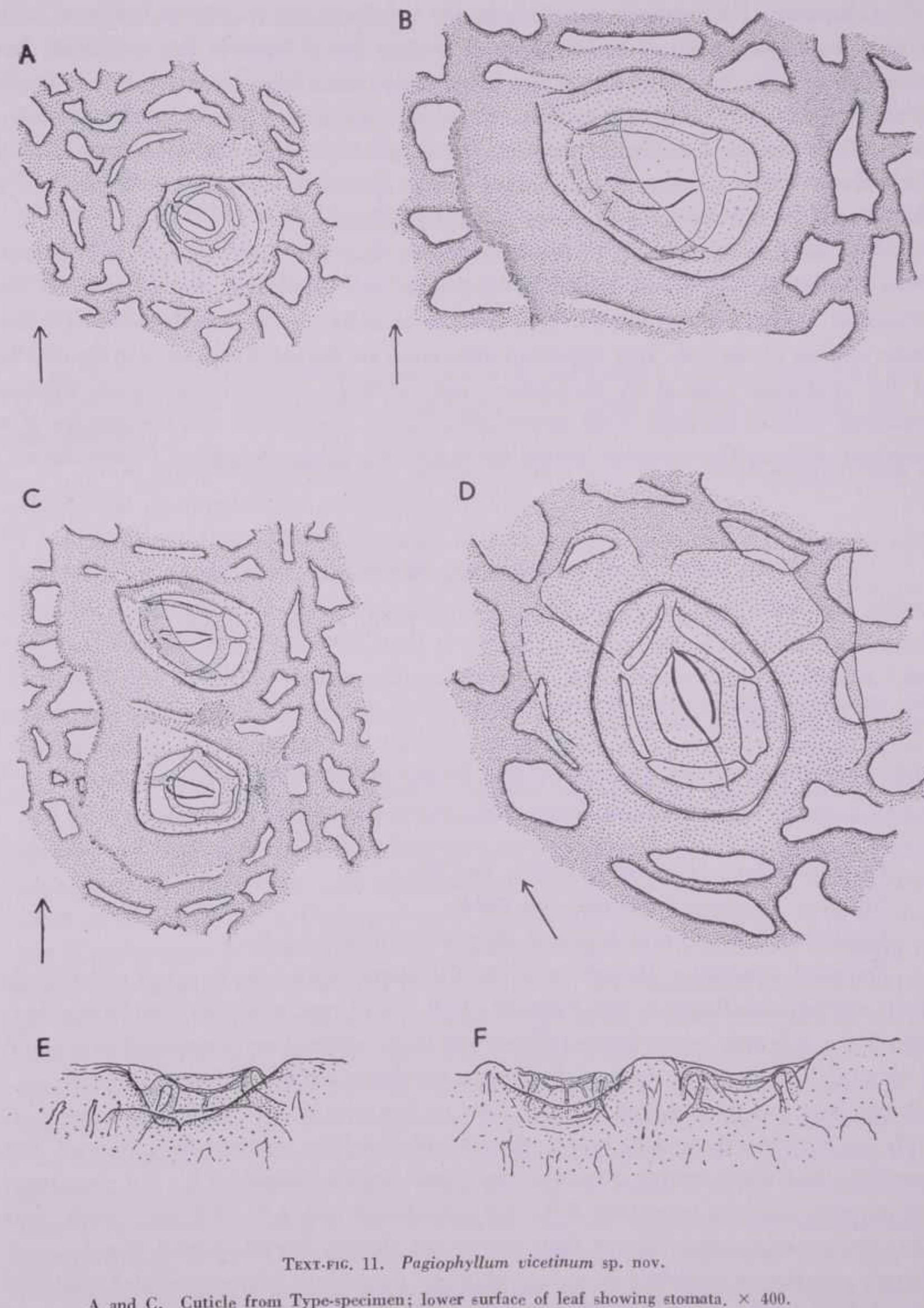
Description: The only specimen of *Pagiophyllum vicetinum* is the Type-specimen No. 5279, which is a compression in a typical piece of the dark grey Rotzo limestone. The external from of the plant is not perfect, but plant substance still remains from which cuticle preparations have been made.

The cuticle provides nearly all the diagnostic characteristics of *P. vicetinum*, but the account has had to be limited to the one good preparation figured. The stomata are deeply sunken and their morphological interpretation is rather difficult. It is clear that the stomatal apparatus forms a hollow enclosing a chimney-like upgrowth around the guard cells, but it may be that some other interpretation of the cells, different from that given in the diagnosis, would be right.



TEXT-FIG. 10. *Pagiophyllum vicetinum* sp. nov.

A. Part of the Type-specimen No. 5279; the two leaves on the right are impressions in the rock-matrix. Scale equals 10.0 mm.
B. Cuticle from Type-specimen; each dot represents one stoma. × 15.
C. Cuticle from Type-specimen; lower surface of leaf. × 160.
D. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
E. Cuticle from Type-specimen; lower surface of leaf; epidermal-cell walls stippled, hypodermal cells indicated by broken lines. × 400.
F. Cuticle from Type-specimen; upper surface of leaf; epidermal-cell walls stippled, hypodermal cells indicated by broken lines. × 400.
(The arrows run parallel with the long axes of the specimens).



TEXT-FIG. 11. *Pagiophyllum vicetinum* sp. nov.

A and C. Cuticle from Type-specimen; lower surface of leaf showing stomata. × 400.
B. Cuticle from Type-specimen; lower surface of leaf showing stomatal apparatus in detail. × 700.
D. Cuticle from Type-specimen; lower surface of leaf showing detail of stomatal apparatus as seen from below. × 700.
E, F. Three stomatal apparatuses seen in optical section; Type-specimen, × 400.
(Each arrow points along the long axis of the specimen figured).

Comparison: In external morphology, the specimen might easily be confused with one of the larger species of *Brachyphyllum*, or short-leaved forms of *Pagiophyllum*. The rather incomplete nature of the specimen has caused some difficulty in deciding in which genus it should be placed. The extent of the upper leaf-surface is not certain, but there is no doubt that the free part of the leaf does extend beyond the leaf-base, even if only for a short distance. From the cuticle fragment it appears to be rather extensive and I therefore place this specimen in the genus *Pagiophyllum*.

The most similar species, in form and cuticle structure, is *P. maculosum* KENDALL from the Estuarine Series of Yorkshire [KENDALL, 31]. The leaves of *P. maculosum* are sometimes longer, but not always. They both agree in having the stomata confined to the under surface of the leaf. Very important differences are the papillae present in the middle of the epidermal cells of *P. maculosum*, but not in *P. vicetinum;* the much thinner anticlinal walls of the cells of the under surface of *P. maculosum;* and the absence of a cutinised chimney-like structure round the guard cells of the stomata of *P. maculosum*.

PAGIOPHYLLUM ROTZOANUM (MASSALONGO) n. comb.

Plate III, figs. 1-3; Plate IV, figs. 1-5. - Text-fig. 12; Text-fig. 13 A-H.

1851. *Araucarites Rotzanus* - MASSALONGO [40], p. 113. *Nomen nudum*.
1859. *Araucarites Rotzanus* - MASSALONGO [41], p. 70; tav. 22.
1884. *Pachyphyllum Zignoi* SAPORTA [51], p. 410; pl. 183, figs. 1-3.
1891. *Pagiophyllum Zignoi* (SAP.) DE ZIGNO, Ms. *Flora foss.* Vol. III, Coniferae.
1913?. *Pagiophyllum zignoii* (SAP.) n. comb. GRANDORI, Riassunto di Laurea. Name in list.
1913. *Pagiophyllum zignoii* (SAP.) GRANDORI - GRANDORI [17]. Name in list.
1913. *Pagiophyllum zignoii* (SAP.) GRANDORI [18]. Name in list.

Type-specimen: MASSALONGO [41], tav. 22.

Neotype: De Zigno Collection No. 4814.

Localities: Rotzo, Val d'Assa and other places as listed below.

Emended Diagnosis: Branching irregularly alternate, in more than one plane; leafy shoots curved, sub-flexuose, not flattened, 10.0 - 15.0 mm. wide; axis including leaf-bases 2.0 - 2.5 mm. wide; leaves falling from larger stems. Leaves arranged in a spiral of about 3/8; leaf arising from a rhomboidal leaf-base cushion; leaf-base typically 5.0 - 6.0 mm. long and 3.0 - 4.0 mm. broad; base of free part of leaf enlarging rather suddenly on abaxial side to join lower extremity of leaf-base cushion; free part of leaf spreading, but apex curving upward; upper free surface typically 4.0 - 5.0 mm. long; leaf strongly biconvex in section, 3.0 - 4.0 mm. broad and 3.0 - 4.0 mm. thick near base; lower surface more convex than upper, not sharply keeled; lateral margins very obtusely angular or rounded; apex very obtusely pointed or almost rounded (as seen from below), rather acute laterally. Stomata on both surfaces except along lateral margins; structure similar on both surfaces; stomata arranged in longitudinal rows, typically separated by 3 rows of epidermal cells (range 1 - 4); occasional stomata occurring out of line; rows not sunken; stomatal areas of upper and lower surface separated along leaf margin by 7 - 12 epidermal cells; central region of lower surface without stomata. Stomatal apparatus sunken in a shallow pit; subsidiary cells all similar, sunken, form-

ing a perfect ring of 4 - 6; polar and lateral cells not distinguished; exposed surface of subsidiary cell thickened and united with surfaces of adjacent subsidiary cells to form a short hollow chimney extending up to general surface level; protected surface not extending beneath encircling cell; opening polygonal above guard cells. Encircling cells forming margin of pit. Guard-cell surfaces thinly cutinised; aperture variably orientated, often transverse. Epidermal cells isodiametric with rounded corners, typically 35 μ long x 35 μ wide (range 25 - 38 μ long; 25 - 45 μ wide); anticlinal walls 5 μ thick, some with shallow pits; outer walls flat, not sculptured, sometimes slightly thickened. Trichomes absent. Hypodermal cells cutinised; elongated between stomatal rows; short in stomatal rows.

Description: *Pagiophyllum rotzoanum* is the commonest conifer in the flora and it is represented by a large number of specimens. The plant occurs in two main types of preservation:

a) in the dark grey limestone of Rotzo, Val d'Assa etc., as compressions with the cuticle and plant substance still preserved;

b) in the buff-coloured limestone of Pernigotti, as casts of moulds from which all the plant substance has usually disappeared.

In aspect, these two forms of the plant might appear to represent two different species, but specimen No. 4908, itself preserved in the lighter coloured rock-matrix, still retains flakes of cuticle showing characteristics of the species. On this evidence, I have identified other specimens, similarly preserved, with the more common form occurring in the dark grey rock-matrix.

Specimens from the dark grey rock show the form of the leaves and pointed apices, and have provided the cuticle preparations. It was on a specimen of this type that the species was originally founded by Massalongo [41]. Specimens from the buff-coloured rock show the phyllotaxis, the radial symmetry of the shoots, the mode of leaf-attachment and form of the leaf-bases. Some of the leaf-apices look rounded, as in the drawing of the nearest leaf in Text-fig. 12, but this is due to the oxidation of the plant substance. An internal cast of the leaf is thus only seen. An examination of the lateral leaves of the same specimen shows an impression of the original plant substance in the rock matrix. Other leaves of the same specimen (Plate IV, figs. 1, 2) viewed from the underside show the truly obtusely pointed form of the leaf-apex. From his description and drawings, it is almost certain that Saporta founded his species on such a specimen [51].

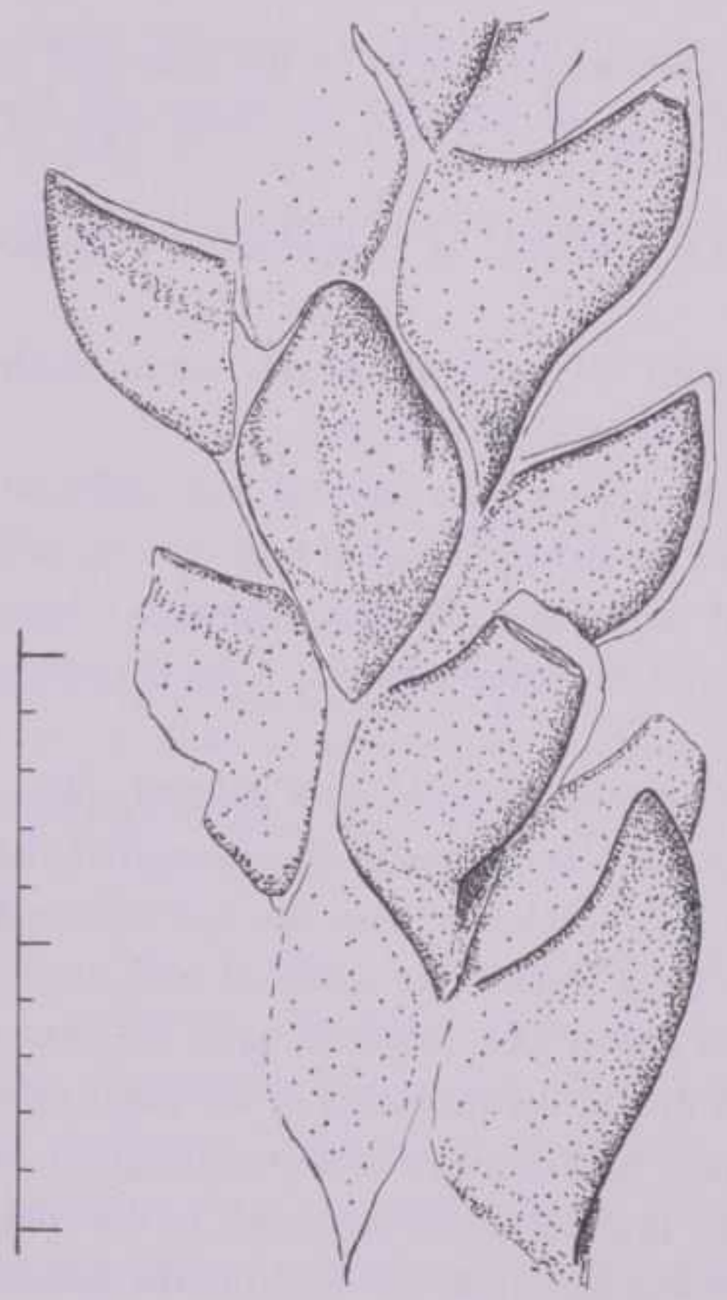
Although the Type-specimen figured by Massalongo [41] is not available, I have no reason to suppose that it differs from the present material and I have, therefore, selected specimen No. 4814 as the Neotype on which to base my emended diagnosis. It exactly resembles the Type-specimen both in form and the rock-matrix in which it is preserved, and differs only in being smaller and less richly branched. Apart from the number, it is labelled « Val d'Assa », and in the catalogue is called « *Pachyphyllum* ». A drawing of it exists among the manuscripts of De Zigno and has the name « *Araucarites Rotzanus* » pencilled on it.

The following specimens have plant substance still preserved, from which cuticle preparations have been made:

4730 - *Brachyphyllum Rotzoanum* - Rotzo
4747 - Rotzo or Val d'Assa
4815 - *Pachyphyllum* - Val d'Assa
4820 & counterpart 4821 - *Pachyphyllum* - Val d'Assa
4822 - *P. Rotzoanum* - Val d'Assa
4823 - *P. Rotzoanum* - Val d'Assa
4825 - *Pachyphyllum* - Rotzo
4826 & counterpart 4828 - *Pachyphyllum* - Rotzo
4850 & counterpart 4851 - *Pachyphyllum* - Scandolara
4861 - Rotzo
4882 - Rotzo
4908 - Monte Carpani (Veronese)
5280 - Rotzo

On external morphology alone, I consider the following specimens as also representing the species:

131 - Flora oolitica di Mt. Raut (Selva di Progno)
132 - Flora oolitica di Mt. Raut (Selva di Progno)
133 - Flora oolitica di Mt. Raut (Selva di Progno)
134 - Flora oolitica di Mt. Raut (Selva di Progno)
135 - Flora oolitica di Mt. Raut (Selva di Progno)
136 - Flora oolitica di Mt. Raut (Selva di Progno)
140 - Flora oolitica di Mt. Raut (Selva di Progno)
4729 - Val d'Assa
4813 - *Pachyphyllum* - Val d'Assa
4816 - *Pachyphyllum* - Val d'Assa
4818 - *Pachyphyllum* - Val d'Assa
4824 - *Araucarites?* - Val d'Assa
4827 - *Pachyphyllum* - Val d'Assa
4829 - *Pachyphyllum* - Val d'Assa
4830 - *Pachyphyllum* - Val d'Assa



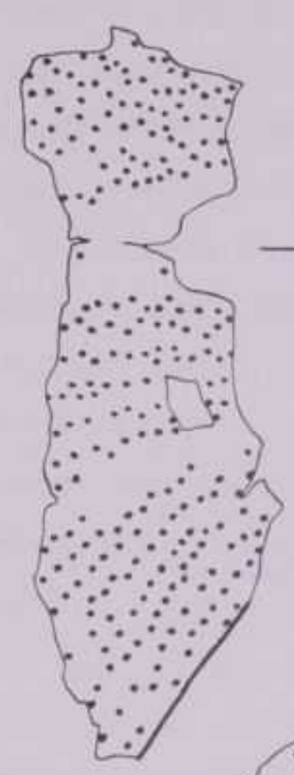
TEXT-FIG. 12.
Pagiophyllum rotzoanum (MASSALONGO) n. comb.

Part of specimen No. 4911, shown also in Plate IV, figs. 1, 2, enlarged to show leaf-form and phyllotaxis. Each leaf is represented by an internal cast; the line running round the right-hand leaves indicates the impression of the outer surfaces in the rock-matrix. Scale equals 10.0 mm.

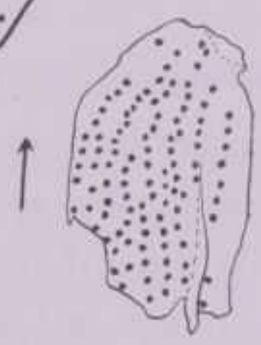
TEXT-FIG. 13. *Pagiophyllum rotzoanum* (MASSALONGO) n. comb. ➟

A, B. Cuticles from two leaves of the Neotype No. 4814; each dot represents one stoma. × 15.
C. Cuticle from Neotype. × 160.
D and F. Folded cuticle from specimen No. 4822 showing two stomata in optical section; broken lines indicate surface view of epidermal cells. × 400.
E and G. Cuticle of Neotype showing epidermal cells and stomata; hypodermal cells indicated by broken lines. × 400.
H. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
(Arrows point along the long axes of the specimens).

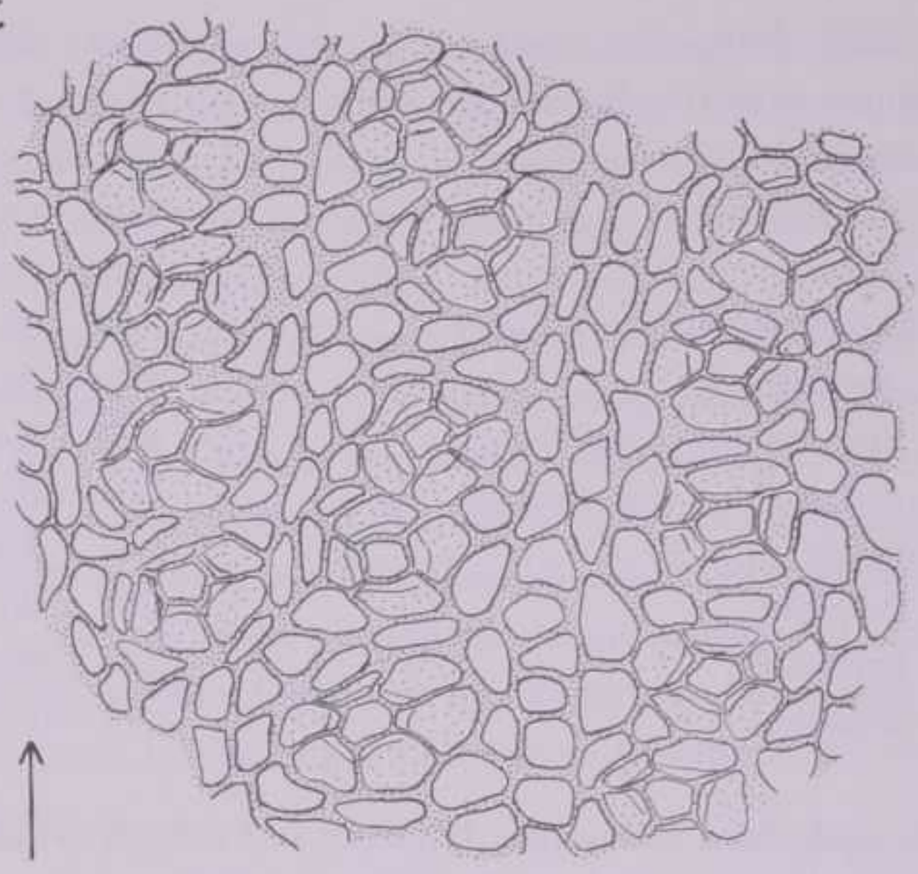
A



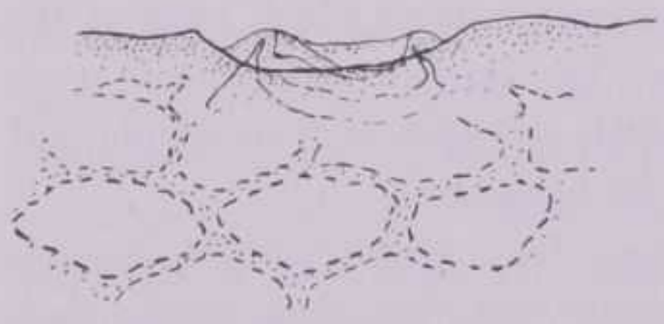
B



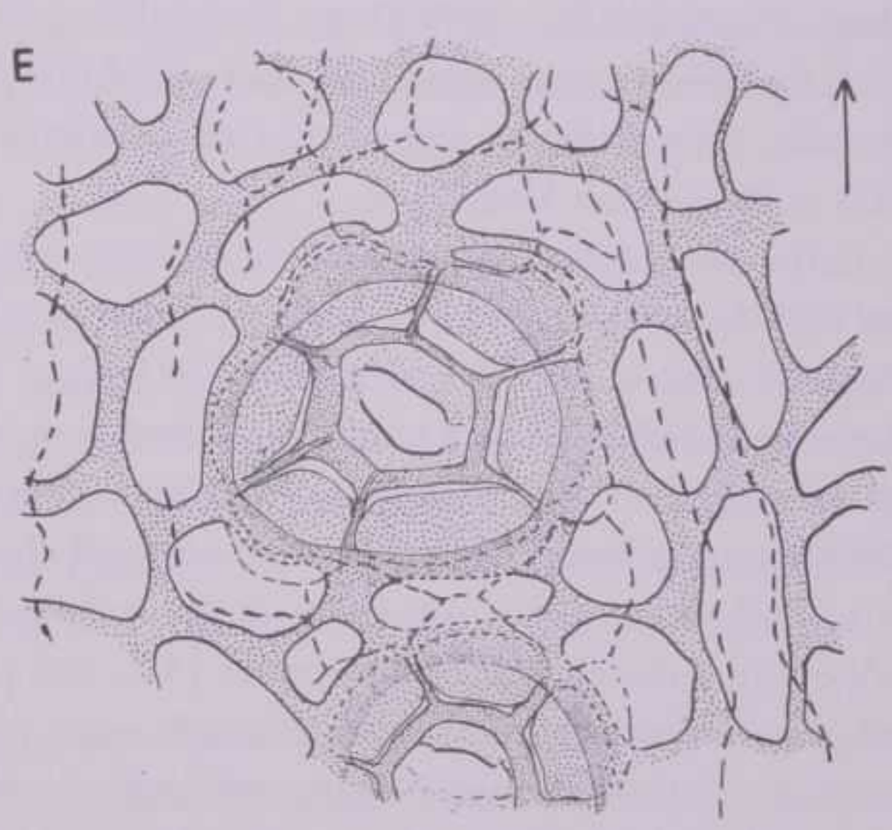
C



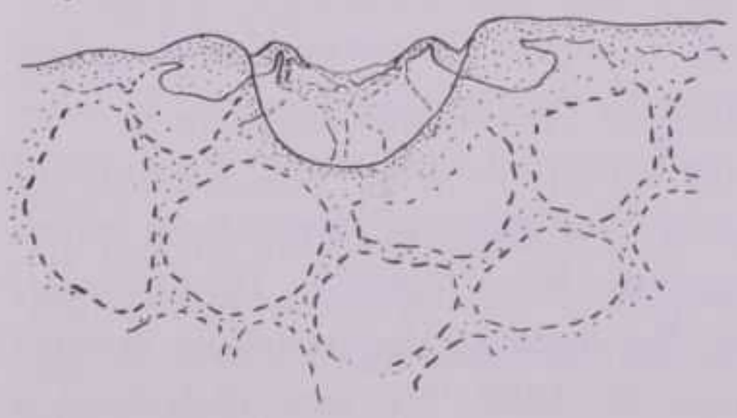
D



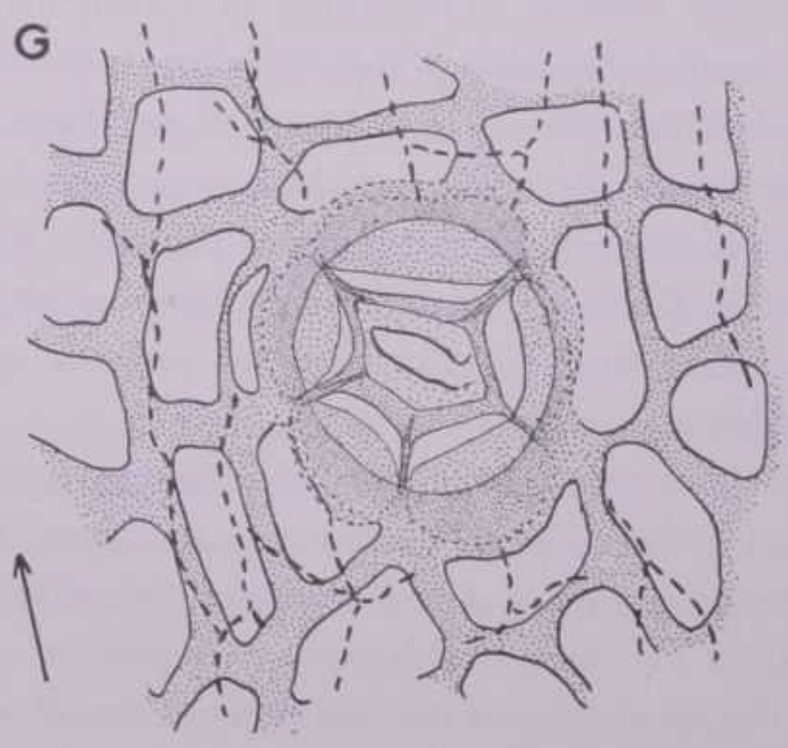
E



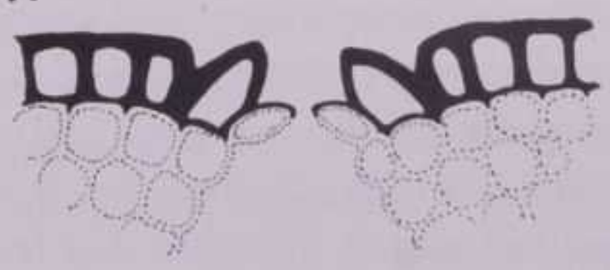
F



G



H



4852 - Valle Zulliani or Scandolara
4854 & counterpart 4855 - Scandolara or Rotzo
4856 - Val d'Assa
4860 - Rotzo
4863 & counterpart 4888 - Rotzo
4869 - Scandolara
4876 - *Araucarites* - Scandolara?
4877 - *Araucarites* - Scandolara?
4885 - Rotzo
4889 - Pernigotti
4890 - Pernigotti
4891 - Pernigotti
4892 - Pernigotti
4894 - Pernigotti
4895 & counterpart 4896 - Pernigotti
4897 - Pernigotti
4898 - Pernigotti
4899 - Pernigotti
4900 - Pernigotti
4901 - Pernigotti
4905 - Monte Carpani (Veronese)
4906 - Monte Carpani (Veronese)
4907 - Monte Carpani (Veronese)
4910 - Monte Carpani (Veronese)
4911 - *Brachyphyllum?* - Veronese

Pagiophyllum rotzoanum typically has curved or subflexuose shoots, the branching of which is alternate or irregular. The branching of every shoot occurs in more than one plane. Specimen No. 4899 shows arrested terminal-bud development, the apex having been replaced by two equal branchlets produced from lateral buds situated immediately beneath, thus giving an appearance of dichotomous growth. The largest specimen (No. 133) is 280.0 mm. long.

The axes of the leafy shoots are typically up to 5.0 mm. in diameter, but the leaves are shed from older and broader axes. Specimen No. 4729 shows a small lateral leafy shoot attached to an older axis, about 10.0 mm. in diameter, from which most of the leaves have fallen leaving only the old leaf-base scars. The leaves of most shoots curve up towards their tips, but a few specimens (Nos. 4890 and 4895 with its counterpart 4896) have the leaves diverging at an angle of about 90° to the axis.

All the identifiable specimens in the collection agree fairly closely with MASSALONGO's original description of the species [41], and I imagine that, from their slender form and their curvature, the ultimate shoots were pendulous. MASSALONGO described the margins as « conspicuously sharp and acute », but an examination of a number of specimens suggests that such was not the case, but instead the angles were very obtuse. He also referred to the apices as « acute and sharp », whereas SAPORTA [51] described them as « *obtusatis* ». This difference is accounted for by the fact that SAPORTA, in every probability, was describing specimens from the buff-coloured rock where the oxidised casts of the plant appear to have some leaves with very blunt apices as viewed from below.

In the manuscript notes of the third Volume of the *Flora fossilis...*, DE ZIGNO describes the branching as dichotomous or alternate. No doubt he was mistaking arrested terminal bud development, as seen in specimen N. 4899, for true dichotomous branching.

The structure of the cuticle is seen well in a number of preparations, and there is little variation from specimen to specimen. The stomatal rows are absent along the two lateral margins, and also from the central region of one surface. This can be seen in Text-fig. 13 A, which is a drawing of a piece of cuticle from a leaf of the Neotype No. 4814. It represents almost the entire expansion of one surface and part of the other, but lacks the apical region. In the drawing, the central zone and one marginal zone, each devoid

of stomata, are shown. The cuticle of both surfaces of a leaf of specimen No. 4822 shows one surface with a median zone lacking stomata, but the other surface is completely covered with stomata. It is not known, however, which of these is the upper surface of the leaf, but I prefer to regard the surface with generally distributed stomata as the upper.

Specimen No. 4826 and its counterpart No. 4828 (Plate IV, fig. 5) show some variation, but I do not consider them as having characteristics sufficiently different to enable their being separated from typical specimens of *P. rotzoanum*. The two specimens have leaves of the same general shape, but they are somewhat narrower and taper more towards the apex. An examination of the cuticle of No. 4828 shows the stomata arranged in four definite bands. Stomata are absent from the middle region of both the upper and lower surfaces of the leaf, as well as along the angular lateral margins. The subsidiary cells of the stomata commonly number four, but some stomata have five. Since there are no other marked differences I prefer to consider these two specimens as representing a somewhat extreme form.

Comparison: *Pagiophyllum rotzoanum* is very close to the Lower Liassic *P. peregrinum* (L. & H.) SCHENK. BRONGNIART, in a letter to DE ZIGNO dated 1855, remarks upon the similarity of « *Araucarites Rotzanus* » to « *Araucarites peregrina* L. & H. or *Brachyphyllum peregrinum* BRONGN. », but he points out that in the English plant the leaves are « imbricate, not spreading (étalées), and pointed (aiguës), but shorter ». MASSALONGO in his description of the species [41] says that « it most closely simulates... *Araucarites peregrinus* L. & H., but it differs in the lack of ribs on the leaves and lack of minute points which ornament the margins of the leaves of *A. peregrinus*, where the leaves are broader, shorter and less acute ». *P. rotzoanum* differs slightly, also, from *P. peregrinum* in having the lateral angles of the leaf less sharp. They are described as « sharply keeled » in *P. peregrinum* by KENDALL [31]. *P. rotzoanum* is certainly also branched in more than one plane, but in *P. peregrinum* the branches all arise in the same plane [KENDALL, 31].

SAPORTA [51] compares *P. rotzoanum* with *P. cirinicum* SAP. and *P. rigidum* (POM.) SAP. (non *P. rigidum* (PHILLIPS) HARRIS). From *P. cirinicum* it differs in having the leaves relatively thicker, and from *P. rigidum* in its very much smaller and less acute leaves.

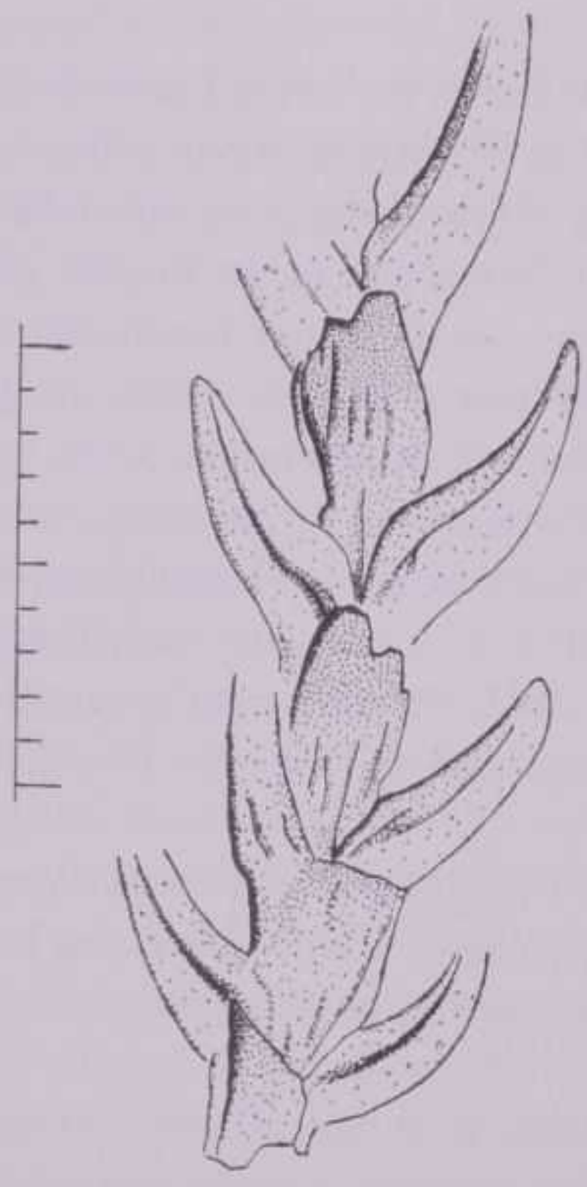
In its cuticle structure *P. rotzoanum* is also close to *P. peregrinum*, but there are some differences. In *P. rotzoanum* the stomatal rows are much better defined because the stomata are more crowded in their rows. Another difference is that the epidermal-cell surfaces are smooth in *P. rotzoanum*, but striated in *P. peregrinum*. *P. sewardi* KENDALL is rather more different, having numerous ring-like trichome bases [KENDALL, 31].

The cone-bearing shoots described by CARPENTIER as *Elatides peregrina*, and identified by him with *Pagiophyllum peregrinum* [8], are also different from *P. rotzoanum*. One difference is that the epidermal cells and the stomata of his *E. peregrina* are much smaller, and the cells are usually elongated. I suspect that it is also different from the English *P. peregrinum*.

PAGIOPHYLLUM VERONENSE sp. nov.

Plate V, fig. 1. - Text-fig. 14; Text-fig. 15 A-E.

Type-specimen: De Zigno Collection No. 4845.
Locality: Roverè di Velo.
Diagnosis: (Branching not known); leafy shoot 9.0 mm. wide; axis including leaf-bases 2.0 - 2.5 mm. wide. Leaves arranged in a spiral of about 2/5, partly concealing leaf-bases. Leaf diverging at an angle of about 45° to the stem; upper part curving slightly forwards; lower part continuing without constriction on to leaf-base; free parts of leaves not flattened into one plane; leaf typically 7.0 mm. long, 2.5 mm. broad and 2.0 mm. thick near base; upper surface 5.0 mm. long; free part tapering gradually to a

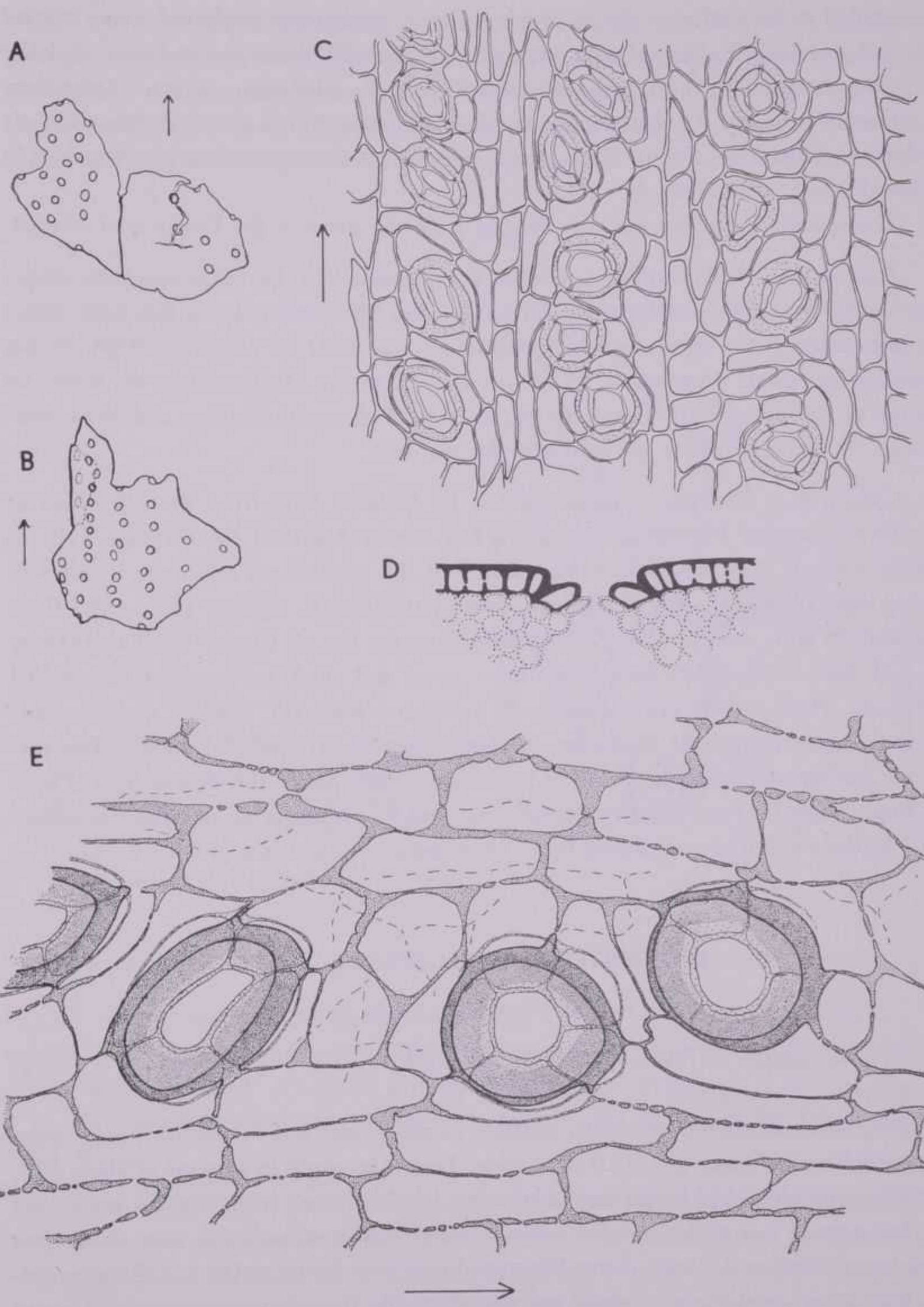


TEXT-FIG. 14.

Pagiophyllum veronense sp. nov.

Part of the Type-specimen No. 4845, shown also in Plate V, fig. 1, enlarged to show phyllotaxis, leaf-form and leaf-bases. Scale equals 10.0 mm.

blunt apex; biconvex in section; lower surface more convex than upper, not keeled (upper side inadequately known); lateral margins angular, entire, not spiny or scarious; stomatal rows conspicuous on both surfaces. Cuticle thin. Stomata on both surfaces except along lateral margins; structure similar on both surfaces; stomata confined to longitudinal rows, typically separated by 4 rows of epidermal cells (range 1 - 7); rows not sunken. Stomatal apparatus with a perfect ring of 4 - 5 specialised subsidiary cells; cells wholly sunken, all similar; polar and lateral cells not distinguished; exposed surfaces of subsidiary cells flat, not sculptured, somewhat thickened, ending at a rounded rim over the guard cells. Encircling cells forming a more or less complete ring at same level as rest of general epidermis; encircling cell pit forming a conical depression with a circu-



TEXT-FIG. 15. *Pagiophyllum veronense* sp. nov.

A, B. Cuticle from Type-specimen No. 4845; each circle represents one stoma. × 29.
C. Cuticle of Type-specimen. × 160.
D. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
E. Cuticle of Type-specimen showing stomata; broken lines indicate hypodermal cells. × 400. (Each arrow points along the long axis of the specimen figured).

lar opening to the surface; edge of opening with a continuous thickened rim. (Guard cells not observed). Epidermal cells rectangular, elongated between stomatal rows, typically 50 - 90 μ long x 18 μ wide; cells of stomatal rows of varied shape, often broader than long; anticlinal walls 3 - 4 μ thick, interrupted by many pits; outer walls thin, flat, not sculptured. Trichomes absent. Hypodermal cells elongated between stomatal rows; short in stomatal rows; outlines thinly cutinised.

The specific name *veronense* is derived from the name of the Province of Verona.

Description: *Pagiophyllum veronense* is represented by the Type-specimen alone. The locality (from the catalogue) is Roverè di Velo. The small piece of limestone shows the impression of the shoot, on which only small fragments of plant substance remain available for cuticle preparation. In the drawing (Text-fig. 14), therefore, the leaves on the top of the figure really belong to the far side of the original shoot and show their abaxial, or under, surfaces and a little of the leaf-base.

Comparison: The most similar shoot is *P. liasinum* Sap. from the Infra-Lias or Rhaetic of Portugal [Saporta, 53], which has been redescribed by Teixeira [70] as *Voltzia ribeiroi*. The shoots look the same, but the cuticles are different, *V. ribeiroi* having short epidermal cells. *P. rigidum* (Pom.) Sap. (non *P. rigidum* (Phillips) Harris) and *P. araucarinum* (Pom.) Sap., both from the French Upper Corallian [Saporta, 51], look similar, but their leaves taper more and show well-marked rhomboidal leaf-bases. Their cuticles are unknown. *P. connivens* Kendall and *P. insigne* Kendall, from the Jurassic of Yorkshire, are both larger shoots, and *P. insigne* differs further in having concave upper surfaces to the leaves [Kendall, 31]. The cuticles of both the English species show short epidermal cells, and *P. connivens* has papillate subsidiary cells, features which are not shared by *P. veronense*.

PAGIOPHYLLUM VALDASSENSE sp. nov.

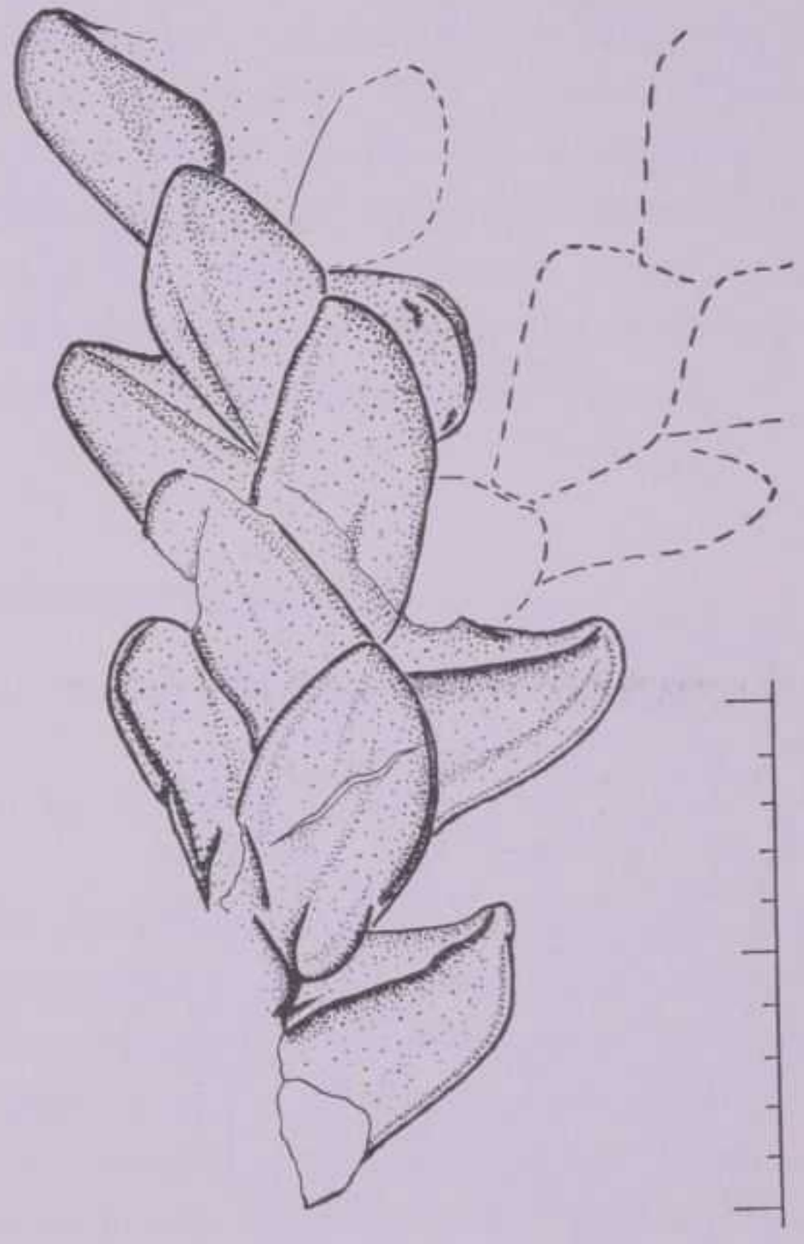
Plate V, fig. 2. . Text-fig. 16; Text-fig. 17 A-F.

Type-specimen: De Zigno Collection No. 4859.

Locality: Val d'Assa.

Diagnosis: Branching alternate, possibly in one plane; leafy shoot 10.0 mm. wide; axis including leaf-bases 2.5 - 3.0 mm. wide. Leaves arranged in a spiral of about 3/8, partially concealing leaf-bases; leaf triangular in side view, with slightly upcurving tip; free part of leaf typically 6.5 - 7.0 mm. long, 3.5 broad and 3.5 mm. thick near base; upper surface 3.0 mm. long; biconvex in section; lower surface much more convex than upper, not keeled; lateral margins diverging from apex at an angle of about 85°, very angular, entire, not spiny or scarious; apex rounded. Stomata on both surfaces, except along lateral margins and middle of lower surface (upper surface inadequately known); rather scattered or in indistinct rows; sometimes adjacent and sharing common subsidiary cell. Stomatal apparatus sunken in a basin-shaped depression; subsidiary cells wholly sunken, forming a ring of 4 - 5 around the guard cells; all similar, polar and lateral cells not distinguished; exposed surface of subsidiary cell raised and

united with surface of adjacent cells to form a hollow cone extending up to general epidermal level; surfaces with faint striations running concentrically round opening, but occasionally radiating away from centre; protected surface cutinised, extending vertically down. Encircling cells in an incomplete ring, forming margins of stomatal depression. Guard-cell surfaces thinly cutinised; orientation of pore variable. Epidermal cells poly-



TEXT-FIG. 16.

Pagiophyllum valdassense sp. nov.

Part of the Type-specimen No. 4859, shown also in Plate V, fig. 2. enlarged to show leaf-form. Two of the leaves were removed for cuticle preparation before the photograph was made and do not, therefore, show in Plate V, fig. 2.

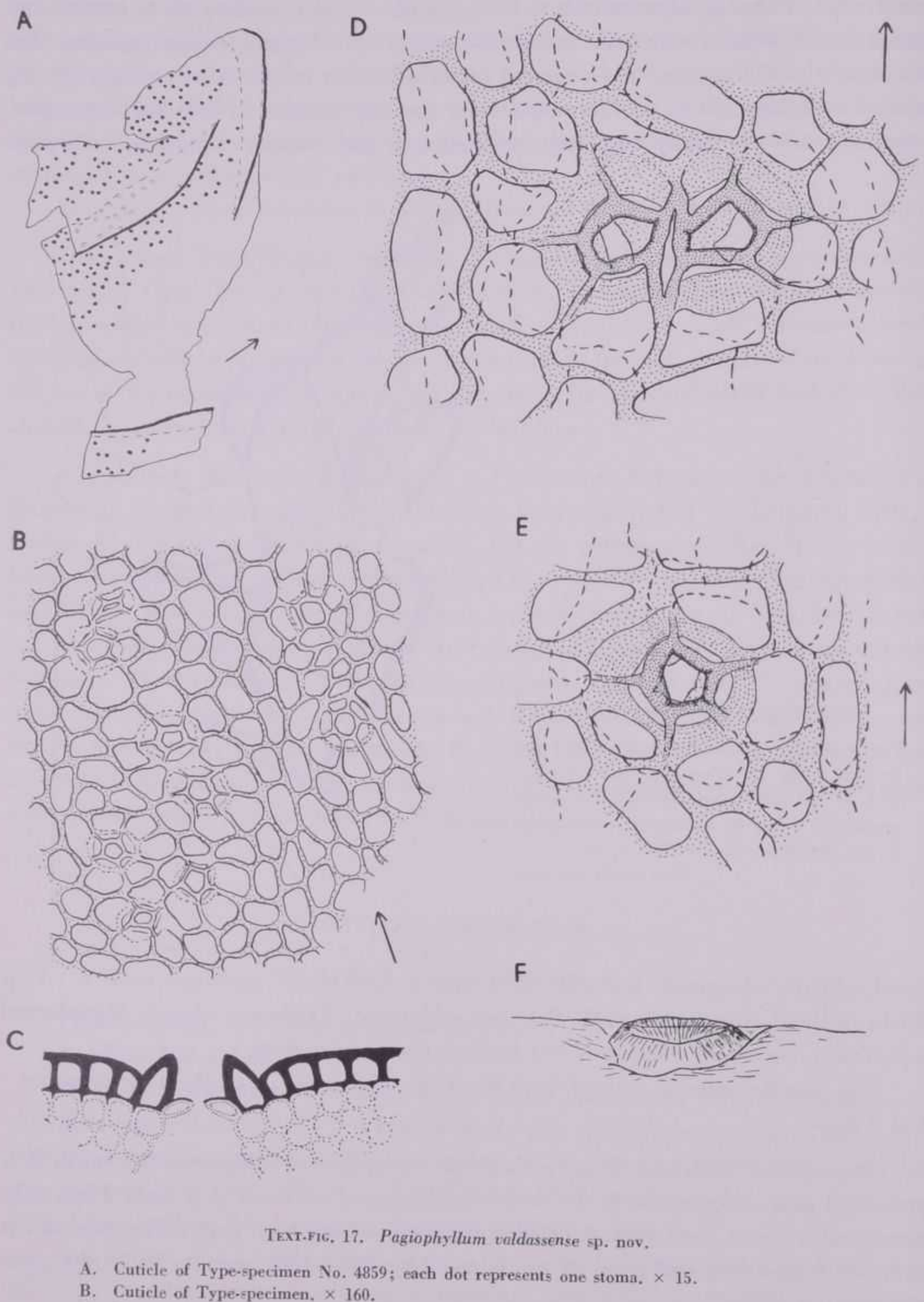
Scale equals 10.0 mm.

gonal, slightly elongated, typically 30 μ long x 28 μ wide; anticlinal walls 6 - 7 μ thick, without pits; outer walls flat, not sculptured. Trichomes absent. Hypodermal cells thinly cutinised; elongated, but isodiametric near stomata.

The specific name is derived from the name of the locality of the Type-specimen - Val d'Assa.

Description: Only the Type-specimen of *Pagiophyllum valdassense* is known. It is preserved as a compression in the dark grey limestone of the Val d'Assa. Plant substance still remains, and from it cuticle preparations have been made. The specimen is about 60.0 mm. long and gives off two lateral branches which seem to be in the same plane.

The stomata are scattered and do not form well-defined rows. They are absent along the lateral margins and from a broad zone down the middle of the lower surface of the leaf. It is not known if a similar region, without stomata, is present on the upper surface. The stomata are usually separated from one another by a varying number of ordinary epidermal cells, but occasionally two may be adjacent, in which case they share a com-



TEXT-FIG. 17. *Pagiophyllum valdassense* sp. nov.

A. Cuticle of Type-specimen No. 4859; each dot represents one stoma. × 15.
B. Cuticle of Type-specimen. × 160.
C. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
D. Cuticle from Type-specimen showing two stomata sharing a common subsidiary cell; broken lines indicate hypodermal cells. × 400.
E. Cuticle from Type-specimen; broken lines indicate hypodermal cells. × 400.
F. Surface of cuticle showing stomatal apparatus in side view. × 400.
(The arrows point along the long axes of the specimens).

mon subsidiary cell (Text-fig. 17 D). The exposed surfaces of the subsidiary cells usually show fine striations running concentrically around the stomatal apparatus, but sometimes radiating from the centre. The outer walls of the epidermal cells cometimes show a granular appearance which is regarded as an effect of preservation. There are certainly no thickened areas or sculpturings on the walls.

Comparison: *Pagiophyllum valdassense* resembles both *P. rotzoanum* (Massalongo) n. comb. and *Brachyphyllum tropidimorphum* sp. nov., and the possibility was considered that it might be an extreme form of one or the other. This was rejected because it is separated from each by several characteristics which do not seem to intergrade.

From *P. rotzoanum* it differs in the distribution of its stomata (scattered, not in well-defined rows), and in having adjacent stomata sharing a common subsidiary cell. From *B. tropidimorphum* it differs in having the stomata scattered, and in having the epidermal cells without a prominent thickening on their outer walls.

PAGIOPHYLLUM MAGNIPAPILLARE sp. nov.

Plate V, fig. 3. - Text-fig. 18 A-H.

Type-specimen: De Zigno Collection No. 4783.
Locality: Roverè di Velo.
Diagnosis: Branching alternate; leafy shoot slender, 2.0 - 3.0 mm. wide. Leaves arranged in a spiral of about 3/8, not flattened into one plane; leaf not spreading, arising from a rhomboidal leaf-base; leaf-base typically 1.5 mm. long and 1.0 mm. broad; leaf biconvex in section; lower surface slightly more convex than upper, not keeled; upper free surface about 1.0 mm. long; lateral margins diverging from apex at an angle of about 45 - 50°, angular, scarious, microscopically denticulate; apex pointed. Stomata on both surfaces, arranged in longitudinal rows not reaching to apex or lateral margins; occasional stomata out of line; stomatal rows not sunken, separated by about 10 rows of ordinary epidermal cells. Stomatal apparatus sunken in a shallow pit; subsidiary cells all similar, forming a ring of 4 - 5 over guard cells; polar and lateral cells not distinguished; exposed surface of subsidiary cell thickened to form a broad ridge. Encircling cells unspecialised, forming an incomplete ring at same level as ordinary epidermal cells. (Guard cells and orientation of pore not known). Epidermal cells rectangular with squarish corners, typically 37 μ long (range 20 - 60 μ) x 18 μ wide; anticlinal walls of both surfaces 2 - 3 μ thick, without pits; outer walls of most cells with a large, solid papilla up to 18 μ high; marginal cells elongated, forming a single series of heavily cutinised, very small, blunt teeth. Hypodermal cells not cutinised.

The specific name *magnipapillare* is suggested by the prominent papillae on the epidermal cells.

Description: Only the Type-specimen, No. 4783 from Roverè di Velo, has plant substance from which cuticle preparations have been made. Several other specimens have similar external characteristics, but I have not identified them as *Pagiophyllum magnipa-*

pillare since there is no plant substance remaining and because they are poorly preserved. The Type-specimen is called « *Brachyphyllum gracile* BRONGN. » in the catalogue.

The specimen is not well-preserved and the measurements given in the diagnosis are only approximate. The branching of the plant seems to have been alternate. The small leaves extend beyond their own leaf-bases and the plant is, therefore, a typical *Pagiophyllum*. The leaves are convex on both surfaces, but the thickness of the leaf is less than its breadth. The margins are angular and scarious, with minute blunt teeth formed by thickly cutinised elongated cells. A very marked feature of the cuticle is the presence of broad, solid papillae on the outermost surfaces of most of the epidermal cells. These are not confined to any particular area or zone, but occur all over the leaf surface.

Comparison: *Pagiophyllum magnipapillare* might be confused with *P. gracillimum* ADAMS [1]. Both species have slender shoots with leaves with microscopically denticulate margins. *P. magnipapillare* differs from *P. gracillimum* in having its thin-walled epidermal cells much more regularly rectangular, and in the presence of the very prominent cuticular papillae on the epidermal cells.

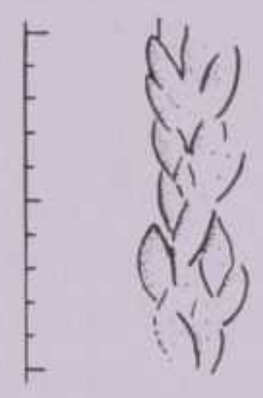
These very prominent papillae on the epidermal cells are also characteristic of the Liassic *Brachyphyllum scotti* KENDALL [32]. However, *P. magnipapillare* has epidermal cells much narrower than those of *B. scotti*, and the leaves are much longer. A further difference is the presence of a scarious denticulate margin to the leaf; in *B. scotti* the margin is always entire.

Haiburnia blacki HARRIS [24] also has scarious denticulate leaf margins, and small leaves of a similar shape to those of *P. magnipapillare*. However, in *P. magnipapillare* the leaves are biconvex in section (those of *H. blacki* are crescentic) and they lack the single vein characteristic of the genus *Haiburnia*. In addition the stomata of *H. blacki* are scattered, and its epidermal cells do not have the large surface-papillae.

TEXT-FIG. 18. *Pagiophyllum magnipapillare* sp. nov. →

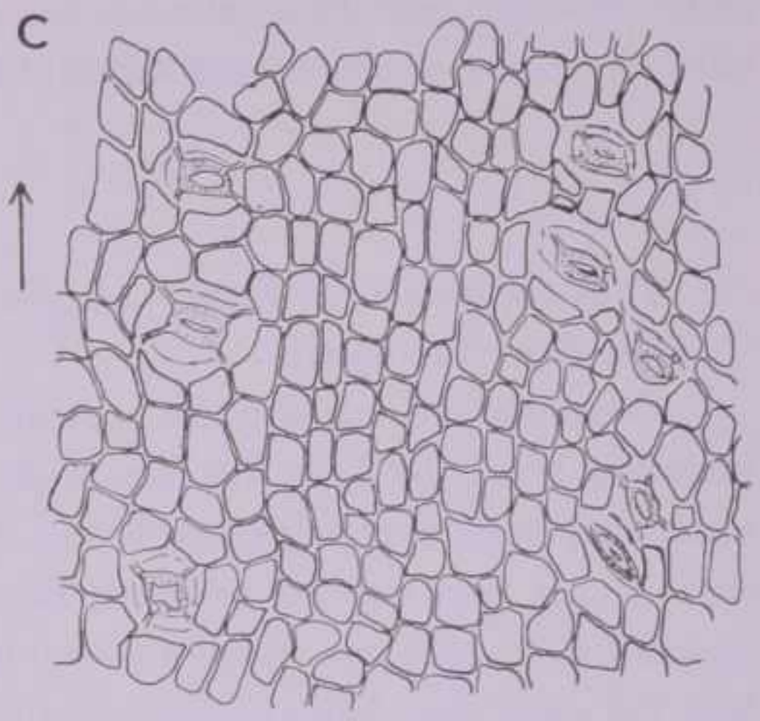
A. Type-specimen No. 4783; part of a shoot to show leaf-form. Scale equals 10.0 mm.
B. Cuticle from Type-specimen; each dot represents one stoma; slide A. × 15.
C. Cuticle of Type-specimen; slide A. × 160.
D. Stoma from Type-specimen; slide A. × 400.
E. Epidermal cells showing the large cuticular papillae on the outer walls; slide A. × 400.
F. Two stomata from Type-specimen; slide A. × 400.
G. Lateral margin of a leaf showing cells forming thickly cutinised teeth; Type-specimen; slide B. × 400.
H. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
(The arrows run parallel with the long axes of the specimens).

A



B

C



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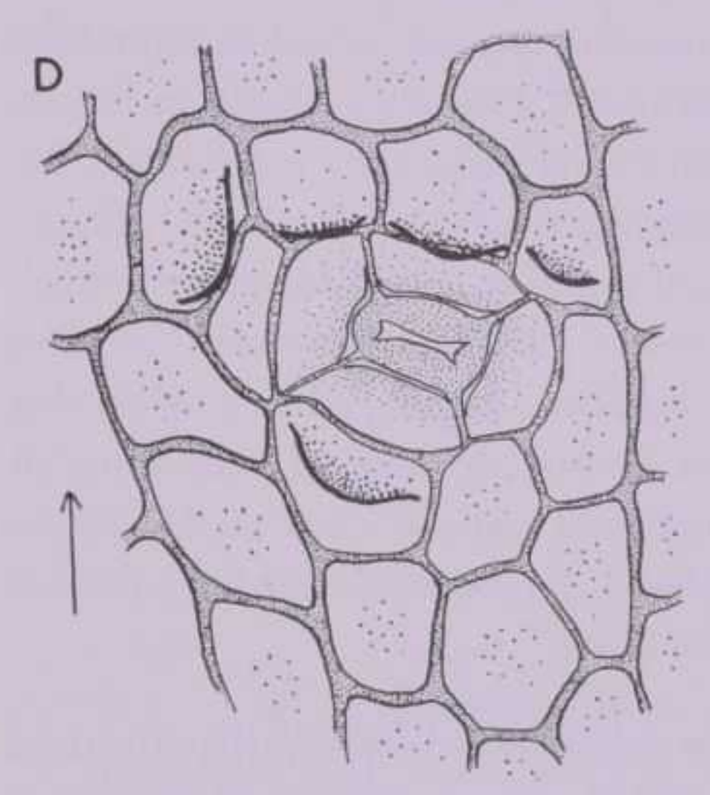
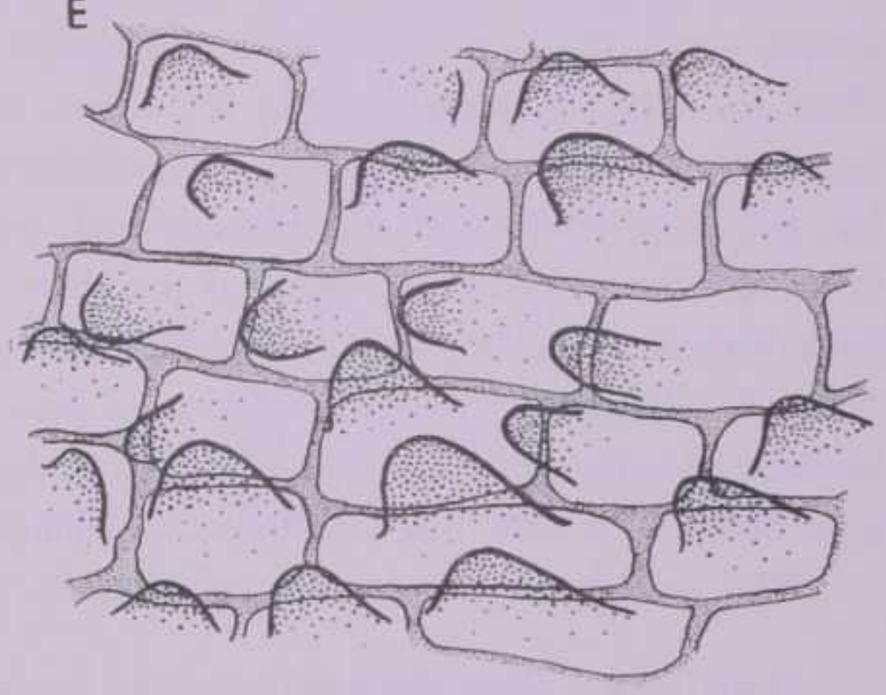


E



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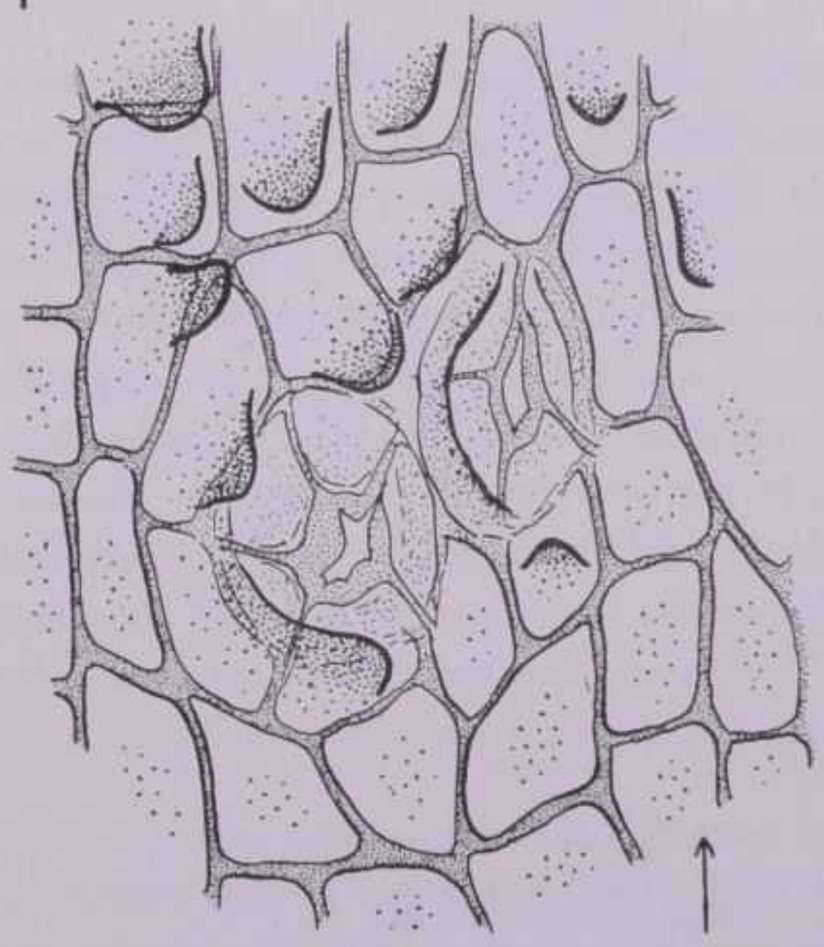

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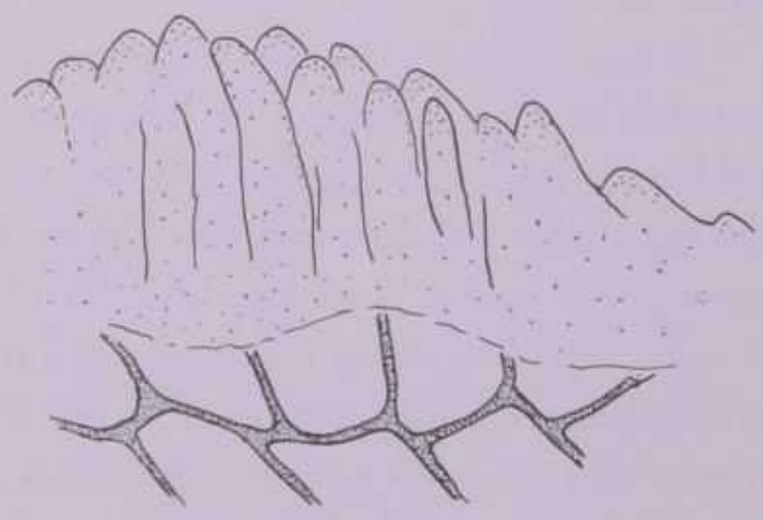
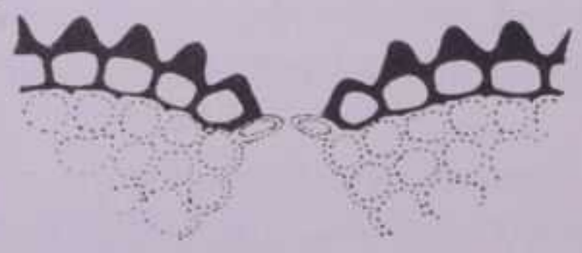


H



PAGIOPHYLLUM ROBUSTUM sp. nov.

Plate V, fig. 4. - Text-fig. 19 A-D.

Type-specimen: De Zigno Collection No. 5281.

Locality: Pernigotti.

Diagnosis: (Branching not known); leafy shoot stout, 13.0 - 18.0 mm. wide; axis including leaf-bases 7.0 - 8.0 mm. wide. Leaves arranged in a spiral of about 5/13, almost completely concealing leaf-bases; leaf diverging at an angle of about 45° to the stem; upper part curving forward; free parts of leaves not flattened into one plane, typically 8.0 - 10.0 mm. long, 4.0 mm. broad and 5.0 mm. thick near base; upper surface 7.0 - 8.0 mm. long; leaf tapering to a blunt apex; biconvex in section; lower surface slightly more convex than upper; lateral margins angular. (Cuticle imperfectly known from fragments; stomatal distribution unknown). Stomata confined to longitudinal rows, typically separated by 2 - 4 rows of epidermal cells; rows not sunken. Stomatal apparatus with a ring of 5 - 7 specialised subsidiary cells; cells sunken, all similar; polar and lateral cells not distinguished; exposed surfaces of subsidiary cells thickened forming ridge round stomatal opening; protected surfaces thickened, extending back beneath encircling cells. Encircling cells unspecialised, forming an incomplete ring. (Guard cells not observed, orientation of pore not known). Epidermal cells rounded, isodiametric, typically 24 μ long x 24 μ wide; anticlinal walls 2 - 3 μ thick, without pits; outer walls flat, not sculptured. Trichomes absent. Hypodermal cells not cutinised.

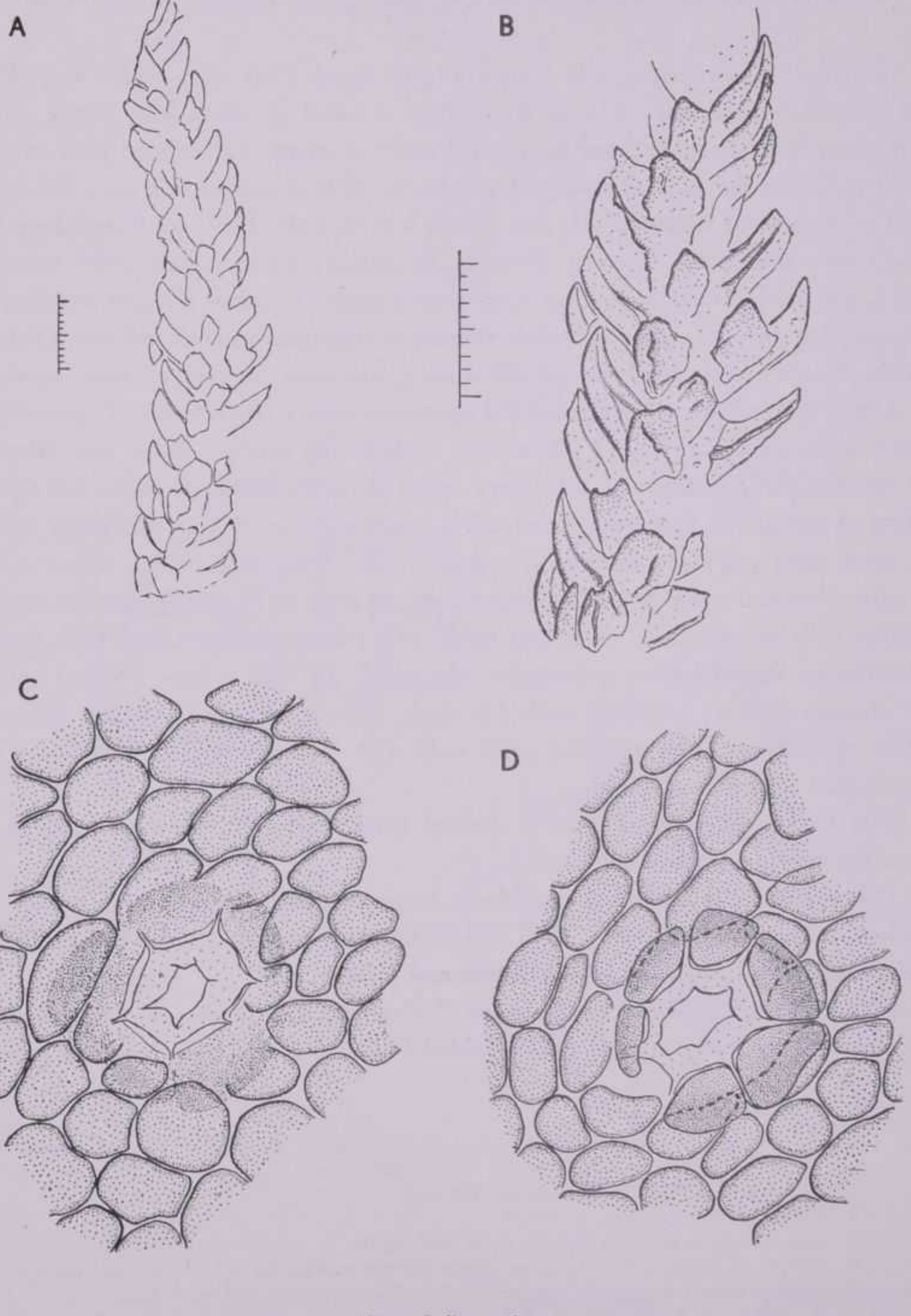
The specific name *robustum* refers to the stout shoot.

Description: *Pagiophyllum robustum* has stout shoots with closely-overlapping thick leaves. The Type-specimen is not well-preserved and does not show clearly the form of the leaf-bases; however, there is no reason to think that they were other than rhomboidal in shape.

It has only been possible to prepare cuticle from the Type-specimen, and the interpretation of these preparations has given some difficulty. The cuticle is very fragmentary and breaks up into a number of small pieces when subjected to the normal treatment with potassium chlorate and nitric acid, followed by dilute ammonia solution. All fragments of the cuticle show a peculiarity which may be due to either changes brought about by treatment with these chemicals or during fossilisation. The cuticle, itself, and other cutinised membranes are colourless, but the epidermal cells and subsidiary cells are deeply coloured. In addition, the epidermal cells are often separated from one another, but still remain attached to the true cuticular membrane. Similarly the subsidiary cells become separated. It seems to me that in this species the epidermal cells and subsidiary cells had excessive deposits of cutin in their walls and that the dark colouration is due to the carbonised cell contents still remaining inside their heavily cutinised walls.

Comparison: *Pagiophyllum robustum* is most like *P. connivens* KENDALL from the English Upper Lias (Toarcian) and Inferior Oolite (Bajocian *sensu stricto*) [KENDALL, 31]. The Italian species differs in not having papillate subsidiary cells, the absence of a

well-marked rim surrounding the stomatal pit and in having epidermal cells with much thinner anticlinal walls. In addition, *P. robustum* shows the peculiar separation of the epidermal and subsidiary cells.



TEXT-FIG. 19. *Pagiophyllum robustum* sp. nov.

A. Type-specimen No. 5281. Scale equals 10.0 mm.
B. Part of Type-specimen enlarged to show leaf-form. Scale equals 10.0 mm.
C. Stoma and epidermal cells from Type-specimen viewed from above. × 400.
D. Stoma and epidermal cells viewed from below. × 400.

PAGIOPHYLLUM REVOLTINUM sp. nov.

Plate V, figs. 5, 6. - Text-fig. 20 A-G.

Type-specimen: De Zigno Collection Nos. 5275 and 5284 (part and counterpart).
Locality: « Oolite della Bocca di Trappola, presso Revolto, confine Veneto-Tirolese ».

Diagnosis: (Branching not known); leafy shoot 19.0 mm. wide; axis including leaf-bases 2.5 mm. wide. Leaves arranged in a spiral of about 2/5, partly concealing leaf-bases; leaf diverging from stem at an angle of about 45°; upper part sub-falcate, curving slightly forwards; lower part continuing without constriction onto leaf-base; free parts of leaves not flattened into one plane; leaf typically 11.0 - 12.0 mm. long and 1.5 - 1.75 mm. thick, not tapering, biconvex in section; lower surface more convex than upper, not keeled (upper surface inadequately known); lateral margins angular, entire, not spiny or scarious; apex rounded; stomata conspicuous on both surfaces. Cuticle fairly thin. Stomata arranged in longitudinal rows, but rows not very obvious, separated by 3 - 4 ordinary epidermal cells. Stomatal apparatus with a perfect ring of specialised subsidiary cells; subsidiary cells 4 - 5, wholly sunken, all similar; polar and lateral cells not distinguished; surfaces of subsidiary cells flat, not sculptured, somewhat thickened, ending at a rounded ring over guard cells; occasional stomata with subsidiary cells bearing small solid papillae pointing over guard cells. Encircling cells forming a shallow pit with a circular opening to the surface; edge of opening forming a continuous thickened ring; cells at same level as rest of epidermis. (Guard cells not observed). Epidermal cells between stomatal rows rectangular, elongated, 38 - 95 μ long x 16 μ wide; cells near stomata shorter; anticlinal walls 4 μ thick, without pits, with a shallow crevice along middle of each on outer surface; outer walls flat, not sculptured. Trichomes absent. Hypodermal cells not cutinised.

The specific name *revoltinum* is derived from the locality Revolto, near the place where the specimens were collected.

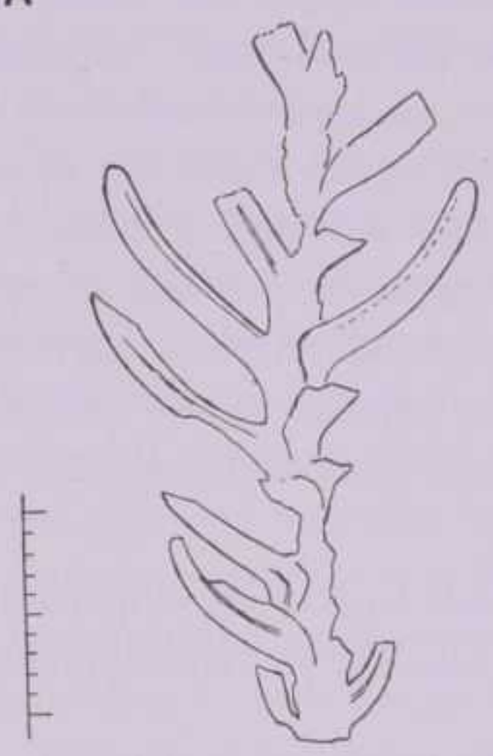
Description: *Pagiophyllum revoltinum* is represented by three specimens - two with cuticle, the Type-specimen No. 5275 and its counterpart No. 5284; the other, No. 5283, lacking cuticle but from the same stratum and locality.

P. revoltinum is placed in the genus *Pagiophyllum* with some doubt, as it shows an extreme form in the elongated parallel-sided leaf, but it has been included chiefly be-

TEXT-FIG. 20. *Pagiophyllum revoltinum* sp. nov. →

A. Type-specimen No. 5284. Scale equals 10.0 mm.
B. Cuticle of Type-specimen. × 160.
C. Cuticle of Type-specimen showing stoma with papillae on subsidiary cells. × 400.
D. Cuticle of Type-specimen showing stoma without papillae on subsidiary cells; shallow crevices along outer edge of anticlinal walls indicated by close dotting. × 400.
E, F. Cuticle of Type-specimen; each circle represents one stoma; E shows non-stomatal region. × 29.
G. Reconstructed transverse section through stoma; cutinised walls shown black, uncutinised walls dotted.
(Arrows point along the long axis of each specimen).

A



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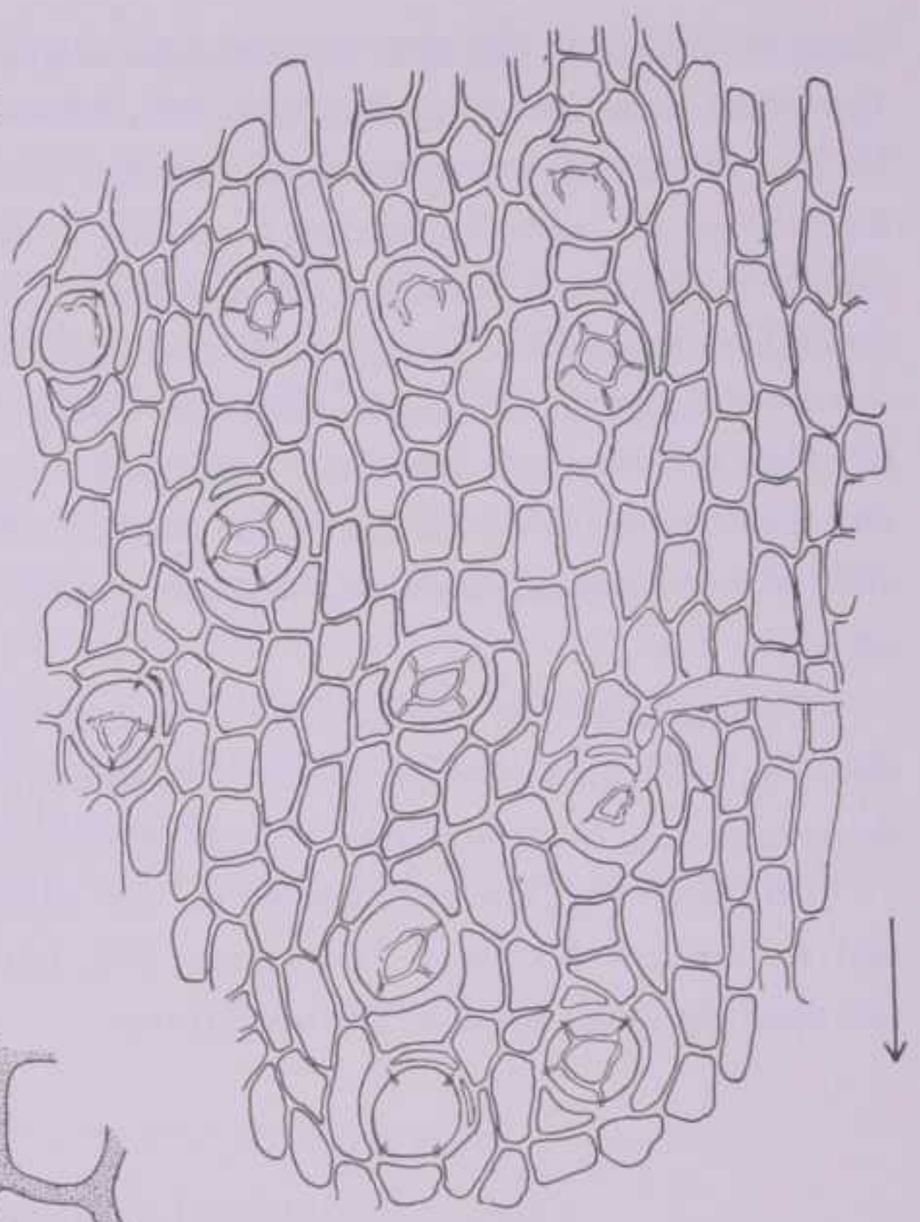

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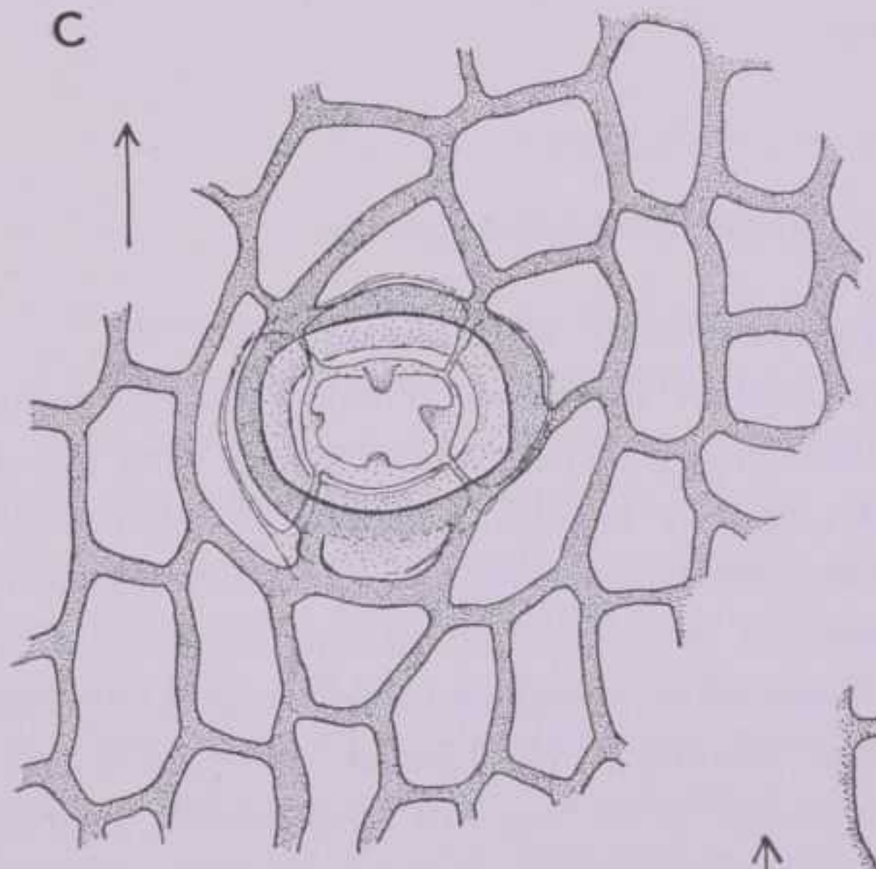

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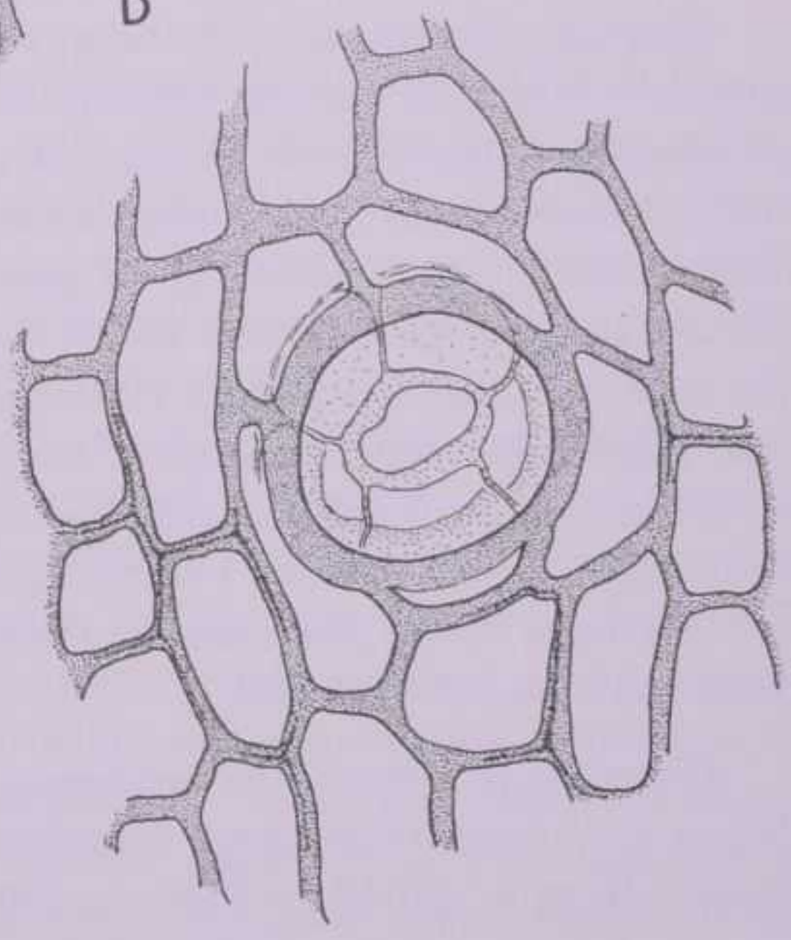
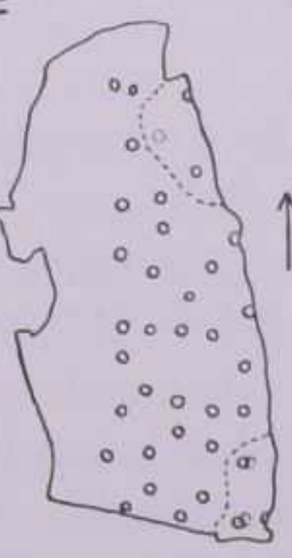


E



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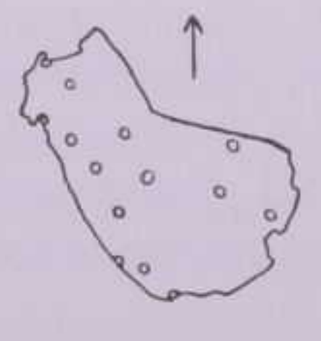

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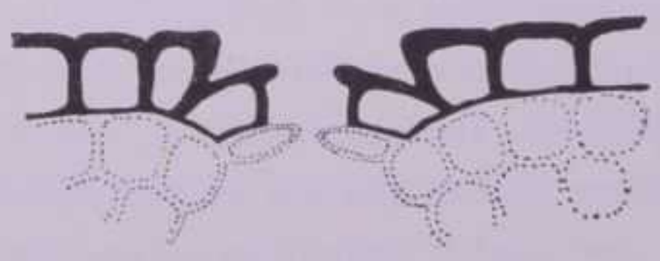


cause its cuticle is like that of more typical species. The specimen looks almost as though the leaves were in two ranks; there are, however, ones on the upper side which have broken short, and examination of Text-fig. 20 A shows the leaves to have been spirally inserted on the axis. I have not been able to decide whether the broken leaves were originally more or less flattened into the plane of those seen along the sides, but there is no indication of their being constricted or twisted where they join their leaf-bases.

One fragment of cuticle (Text-fig. 20 E) shows an elongated area devoid of stomata. This is thought to represent the region along the lateral margin, but it is not certain and may be the middle of one of the surfaces. The cuticular papillae on the subsidiary cells of some stomata are not a common feature, and in some cases are completely absent.

Comparison: No other species of *Pagiophyllum* has such long leaves with parallel sides, and the specimens are unusual in this characteristic. The lack of a midrib prevents their inclusion in *Elatocladus* HALLE [HALLE, 20].

Cuticular papillae are present on the subsidiary cells of *P. connivens* KENDALL and *P. sewardi* KENDALL [KENDALL, 31], but neither of these species has leaves of the same shape as those of *P. revoltinum*.

Form-genus DACTYLETHROPHYLLUM gen. nov.

Generitype: *Dactylethrophyllum peristictum*.

Diagnosis: Branching woody twigs; individual shoots not flattened. Leaves borne spirally, arising from circular leaf-base cushions; free part of leaf longer than broad, spreading, pointing forwards or outwards; strongly biconvex, circular in section, not flattened dorsiventrally; lateral margins not evident; apex rounded. (Venation not known). Cuticle thick. Stomata occurring all over leaf surface, scattered, not forming longitudinal rows, not grouped into bands. Stomatal apparatus haplocheilic; subsidiary cells four to seven, small, not sunken, all similar, forming a cylindrical chamber above guard cells; guard cells sunken, orientated irregularly. Encircling cells unspecialised, forming an incomplete ring. Epidermal cells isodiametric, rounded, not arranged in longitudinal rows; anticlinal walls without pits. Trichomes absent. Hypodermal cells cutinised.

The name of the genus means « finger-stall leaf » and is suggested by the blunt cylindrical shape of the leaves.

Discussion of Genus: The form-genus *Dactylethrophyllum* has been instituted to include a leafy shoot which cannot be included under *Brachyphyllum* BRONGN. or *Pagiophyllum* HEER as defined by KENDALL [30; 31]. Unfortunately no reproductive structures are known, and the affinities of the plant are thus uncertain, but all its vegetative features indicate that it is a conifer.

Dactylethrophyllum is at once distinguished from both *Brachyphyllum* and *Pagiophyllum* by the external form of its leaves and the structure of its cuticle. In gross form, the free part of the leaf of *Dactylethrophyllum* is as long as broad, typically much longer, and always projecting beyond its own leaf-base cushion. In this characteristic, it is

more like *Pagiophyllum* than *Brachyphyllum*. In transverse section, the leaf is strongly biconvex or circular, without angular margins and showing no dorsiventral flattening. It is thus different from the other two genera where the leaves, even when very thick, are distinctly bifacial.

In addition to these differences in external form, the cuticle of *Dactylethrophyllum* shows certain well-defined features which separate it from *Bachyphyllum* and *Pagiophyllum*. An important difference is that of stomatal distribution. The stomata of *Dactylethrophyllum* are scattered at random over the entire leaf-surface; they are not arranged in longitudinal rows and they are not absent from any part of the leaf surface. On the contrary, the stomata of the other two genera are usually arranged in rows, and in some species they may be absent from a tract along the median keel of one or both surfaces, or even the entire upper surface of the leaf. In addition, *Dactylethrophyllum* has stomata in which the subsidiary cells are not sunken, and epidermal cells which are not elongated and which do not form longitudinal rows.

Unfortunately the venation of the leaf is not known, and there is no evidence from the fossil what it may have been like.

DACTYLETHROPHYLLUM PERISTICTUM sp. nov.

Plate VI, figs. 1, 2. - Text-fig. 21 A-E; Text-fig. 22 A-B.

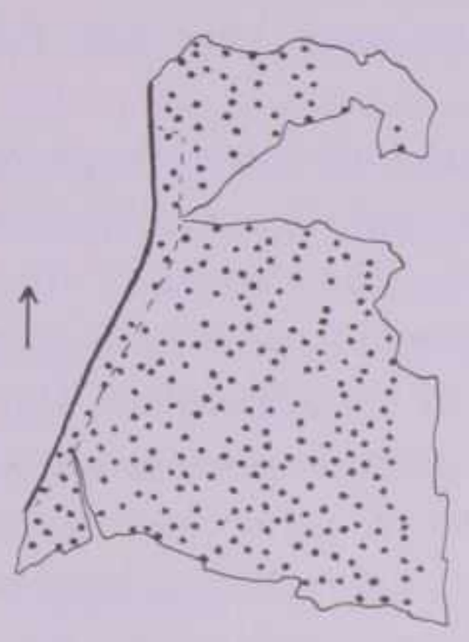
Type-specimen: De Zigno Collection No. 4875.

Locality: Scandolara, Vicentino.

Diagnosis: Branching irregular, probably alternate; leafy shoot 12.0 - 16.0 mm. wide; axis including leaf-bases 4.5 - 5.0 mm. wide. Leaves arranged in a spiral, partly concealing leaf-bases, diverging at an angle of about 45° to the stem, continuing without constriction on to leaf-bases; free parts of leaves not flattened into one plane, typically 7.0 mm. long, 4.0 mm. broad and 4.0 mm. thick near base; upper surface 5.0 - 7.0 mm. long; leaf with parallel sides, not upcurving towards apex; circular in section; convexity of both sides similar; lateral margins absent; apex blunt, rounded. Cuticle thick. Stomata scattered all over leaf surface, not arranged in longitudinal rows. Stomatal apparatus with a ring of 4 - 7 subsidiary cells; subsidiary cells not sunken, forming a deep cylindrical pit about 27 μ deep; cells all similar, polar and lateral cells not distinguished; outward facing surface of subsidiary cell narrow, thinly cutinised, slightly raised; surface lining pit more thickly cutinised. Encircling cells unspecialised, forming an incomplete ring at same level as ordinary epidermal cells. Guard cells sunken at bottom of pit, thinly cutinised; orientation of pore variable. Epidermal cells not arranged in longitudinal rows, polygonal, isodiametric or slightly elongated, with rounded corners, typically 38 μ long x 32 μ wide; anticlinal walls 4 μ thick, without pits; a shallow crevice along middle of outer surface of each; outer walls with a very large thickened area forming a pad occupying most of cell-surface and projecting inwards. Trichomes absent. Hypodermal cells cutinised; isodiametric near stomata, elongated elsewhere.

The specific name *peristictum*, meaning « pricked all over », refers to the random scattering of the stomata over the entire leaf surface.

A



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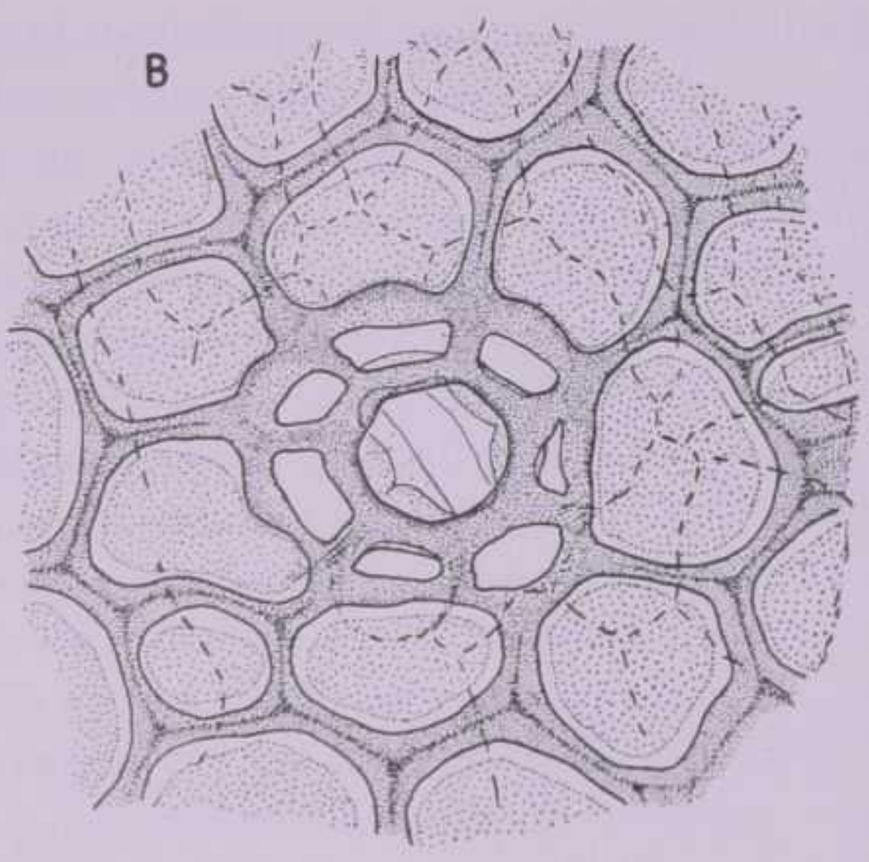

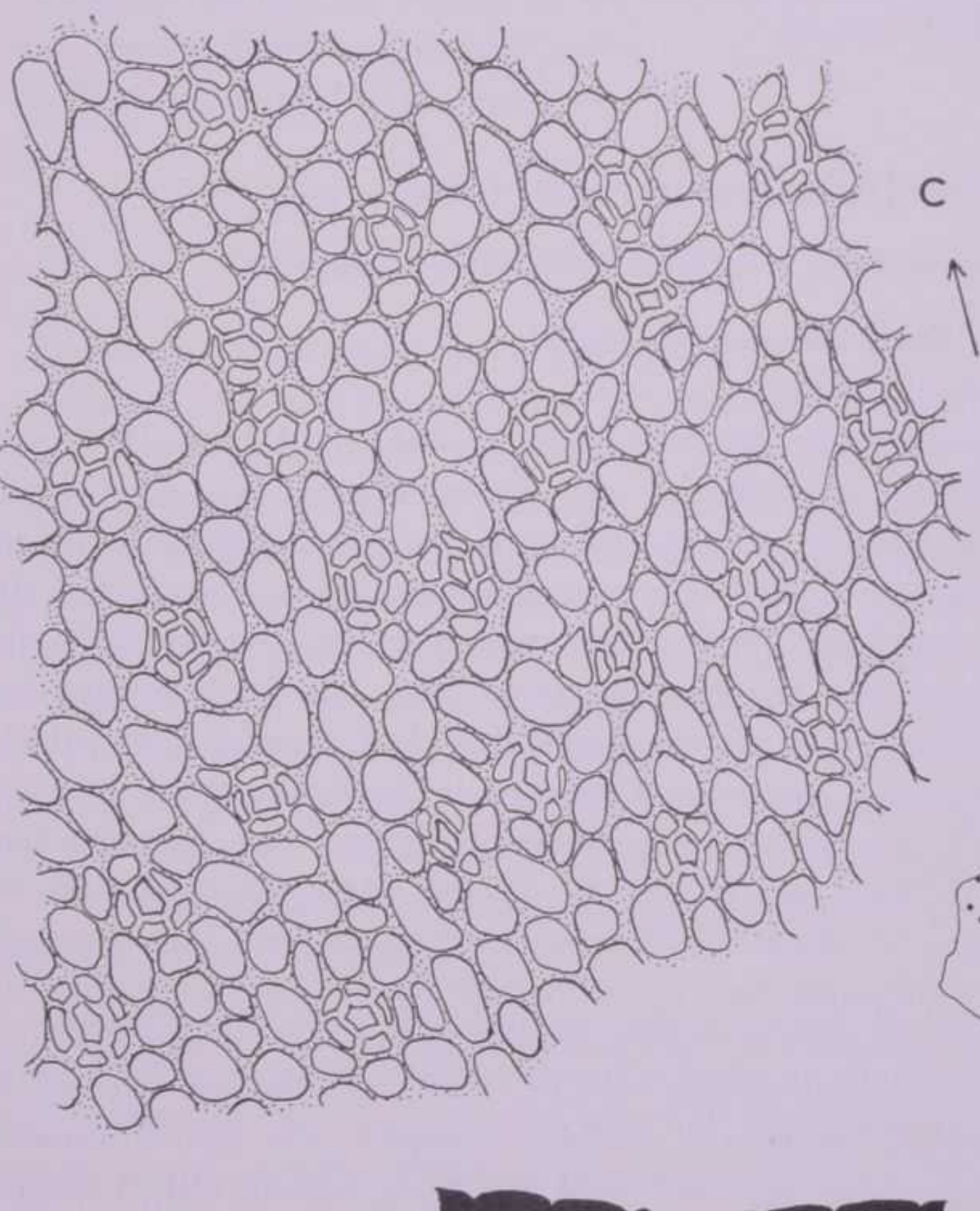

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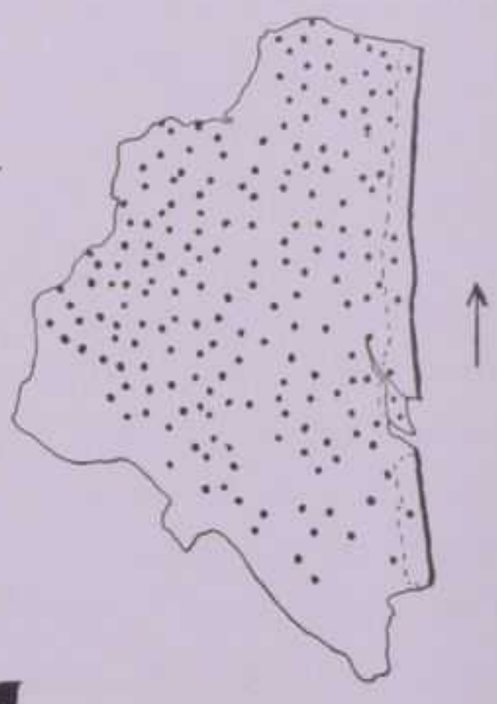

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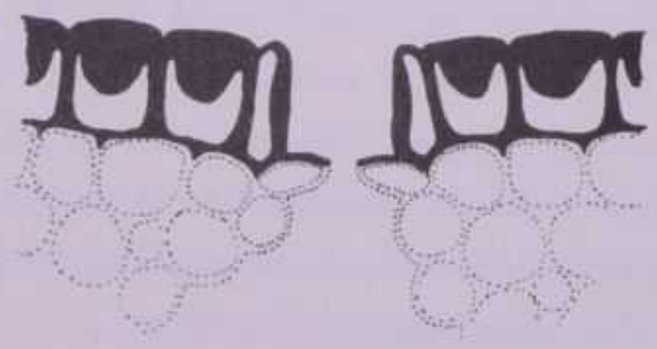
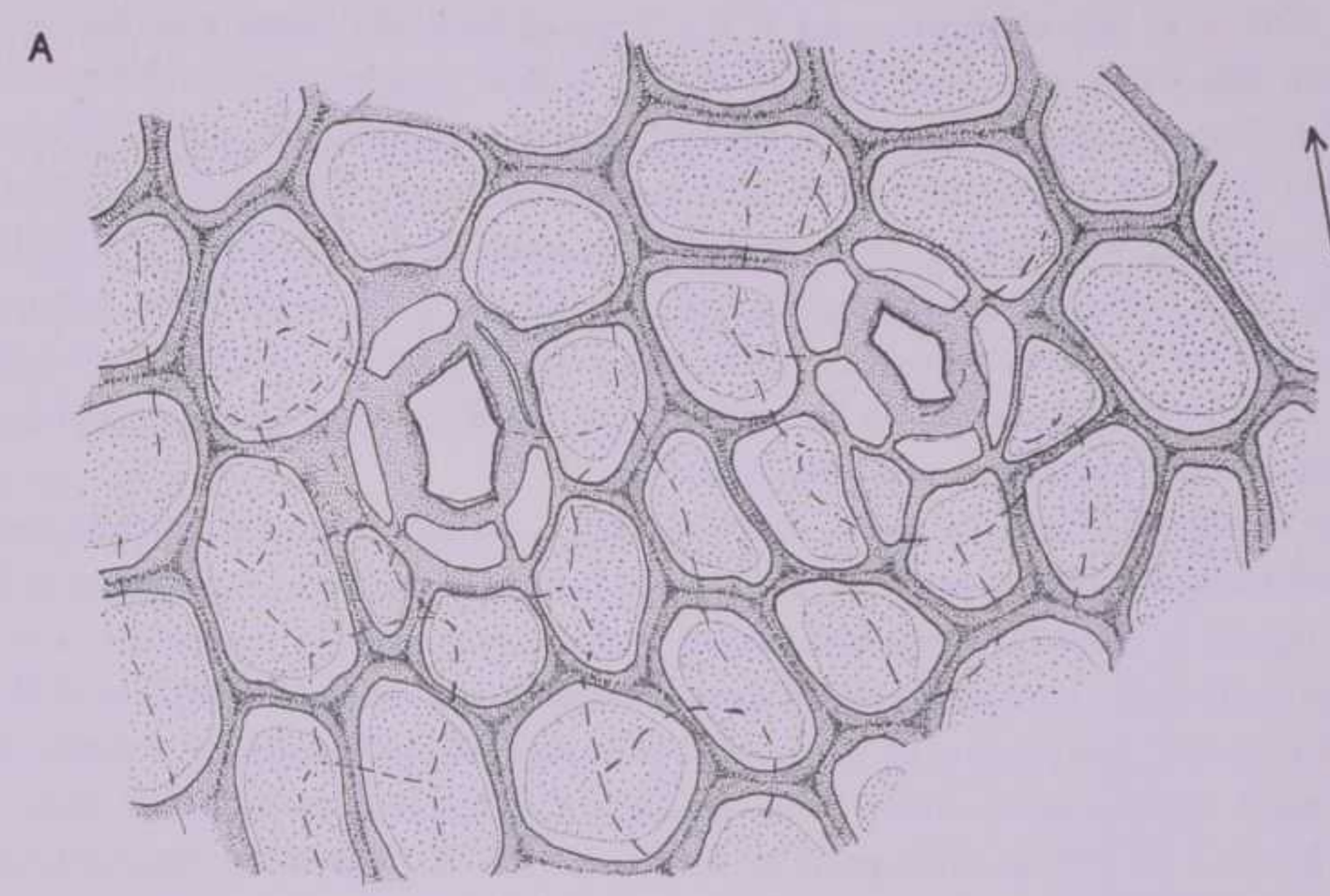
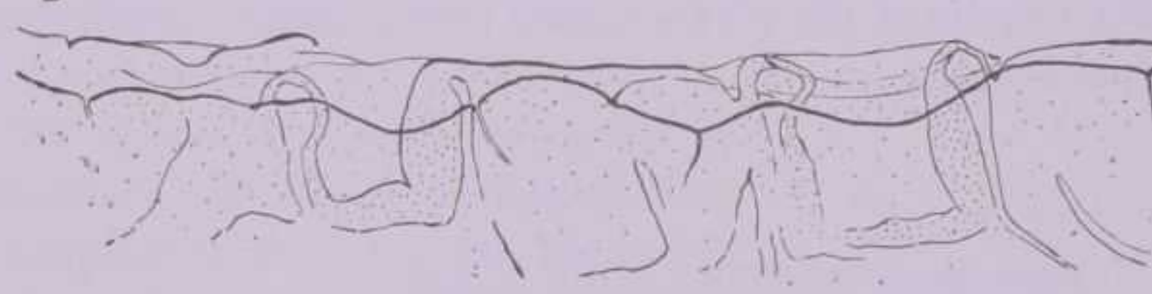






TEXT-FIG. 22. *Dactylethrophyllum peristictum* gen. et sp. nov.

A. Cuticle of Type-specimen; coarsely stippled areas indicate pads of thickening on epidermal cells; shallow crevices along anticlinal walls shown by close dotting; broken lines indicate hypodermal cells; thin, exposed walls of subsidiary cells unshaded; slide B. × 400.
B. Folded cuticle of Type-specimen showing two stomata and epidermal-cell walls in optical section; slide A. × 400.
(Arrow in A runs parallel with the long axis of the specimen).

TEXT-FIG. 21. *Dactylethrophyllum peristictum* gen. et sp. nov.

A. Cuticle from Type-specimen No. 4875; each dot represents one stoma; slide A. × 15.
B. Cuticle of Type-specimen; coarsely stippled areas indicate pads of thickening on epidermal cells; shallow crevices along anticlinal walls shown by close dotting; broken lines indicate hypodermal cells; thin walls of subsidiary cells unshaded; slide A. × 400.
C. Cuticle from Type-specimen showing distribution of stomata; slide A. × 160.
D. Cuticle from Type-specimen; each dot represents one stoma; slide B. × 15.
E. Reconstructed transverse section through stoma and epidermis; cutinised walls shown black, uncutinised walls dotted.
(The arrows point along the long axes of the specimens).

Description: *Dactylethrophyllum peristictum* is represented by only two specimens. Specimen No. 4875, from Scandolara, Vicentino, is labelled « *Brachyphyllum obtusifolium* ZIG. » in the catalogue, and is the Type of both the genus and this species. Specimen No. 4736, also from Scandolara, has cuticle showing similar characteristics.

The Type-specimen is part of a branching and curving shoot about 190.0 mm. long, but it is not known if it is of ultimate branch order. Numerous persistent and spirally arranged leaves arise from partially concealed leaf-base cushions. The leaves generally point outwards and forwards at an angle of about 45° to the stem, but on the lower part of the specimen the angle of divergence may be greater. Each leaf is very thick, and no lateral ridge is present, so I conclude that it had no marked angles at all. The leaf-apex is very blunt and perfectly rounded.

The cuticle is unusually thick, and the rather sparsely scattered stomata, which are distributed at random, occur over the entire leaf surface. There is no particular band or area devoid of stomata. A marked feature is the development of the cuticle overlying the outer walls of the epidermal cells as deep block-like pads extending into, and diminishing the size of, the lumina of these cells. In surface view they appear as much darker and more opaque areas. There is no evidence that these pads projected above the general level of the cuticle. This peculiar feature has, so far, only been seen in *Brachyphyllum tropidimorphum* sp. nov., and I know of no other plant which shows it.

The stomatal apparatus is circular, with the guard cells sunken at the bottom of a deep cylindrical pit. The margins of this pit are formed by the narrow subsidiary cells, which themselves are not sunken.

Form-genus ELATOCLADUS HALLE.

1913. *Elatocladus* HALLE [20], p. 82.

The form-genus *Elatocladus*, as defined by HALLE, is a comprehensive name for sterile coniferous shoots that cannot be satisfactorily assigned to a family.

In its widest sense it includes shoots with linear, single-veined leaves with a pseudodistichous or spiral arrangement. The name is useful for sterile shoots which have been included under *Taxites* BRONGN. [6] and *Palissya* ENDLICHER [10]. It is distinct from the form-genera *Brachyphyllum* BRONGN. and *Pagiophyllum* HEER, which have fleshy, appressed leaves and four-sided, sub-falcate leaves respectively, and the form-genus *Podozamites* BRAUN [4] which has flattened leaves with several veins.

In the collection of DE ZIGNO there are several specimens which I have identified as *Elatocladus*. On external morphology alone I have only been able to distinguish two forms. The cuticle was prepared from the coaly substance of some of the specimens, but in all cases it was so fragmentary that no details of the epidermal structure could be seen.

The three names given by GRANDORI [17] obviously refer to these specimens, but since she gives no descriptions or illustrations I have not been able to decide to which particular ones she may have assigned the names.

ELATOCLADUS VERONENSIS sp. nov.

Plate VI, fig. 3. - Text-fig. 23.

Type-specimen: De Zigno Collection No. 5278.
Locality: Roverè di Velo.

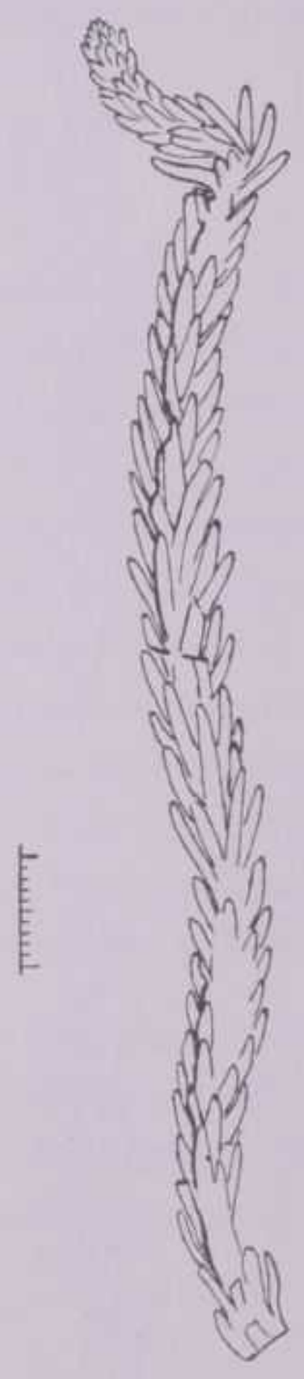
Diagnosis: Sterile conifer shoot; (branching not known). Leaves arranged spirally, not flattened into one plane. Leaf-bases concealed by tips of lower leaves. Leaf dorsiventral, 7.0 - 10.0 mm. long, 1.5 mm. wide; lamina pointing forwards; midrib inconspicuous; apex obtuse.

The specific name *veronensis* is derived from the name of the Province of Verona.

Description: *Elatocladus veronensis* is represented by eight specimens (Nos. 4834; 4837 and counterpart 4840; 4841; 4842; 4844 and counterpart 4848; 5278) of which the Type-specimen shows best the features of the species. All had been collected at Roverè di Velo. Specimen No. 4834 is the largest and measures 160.0 mm. long.

The species is typically represented by sterile shoots with closely overlapping, flattened leaves arranged in a spiral. The midrib is not conspicuous, but it can be seen on the leaves of several of the specimens. There is no indication whatsoever of the lamina of the leaf being constricted at its junction with the stem. All the leaves spread radially from the main axis and they are not orientated into one plane.

I know of no other species that looks quite like this one, and I have, therefore, instituted a new name.

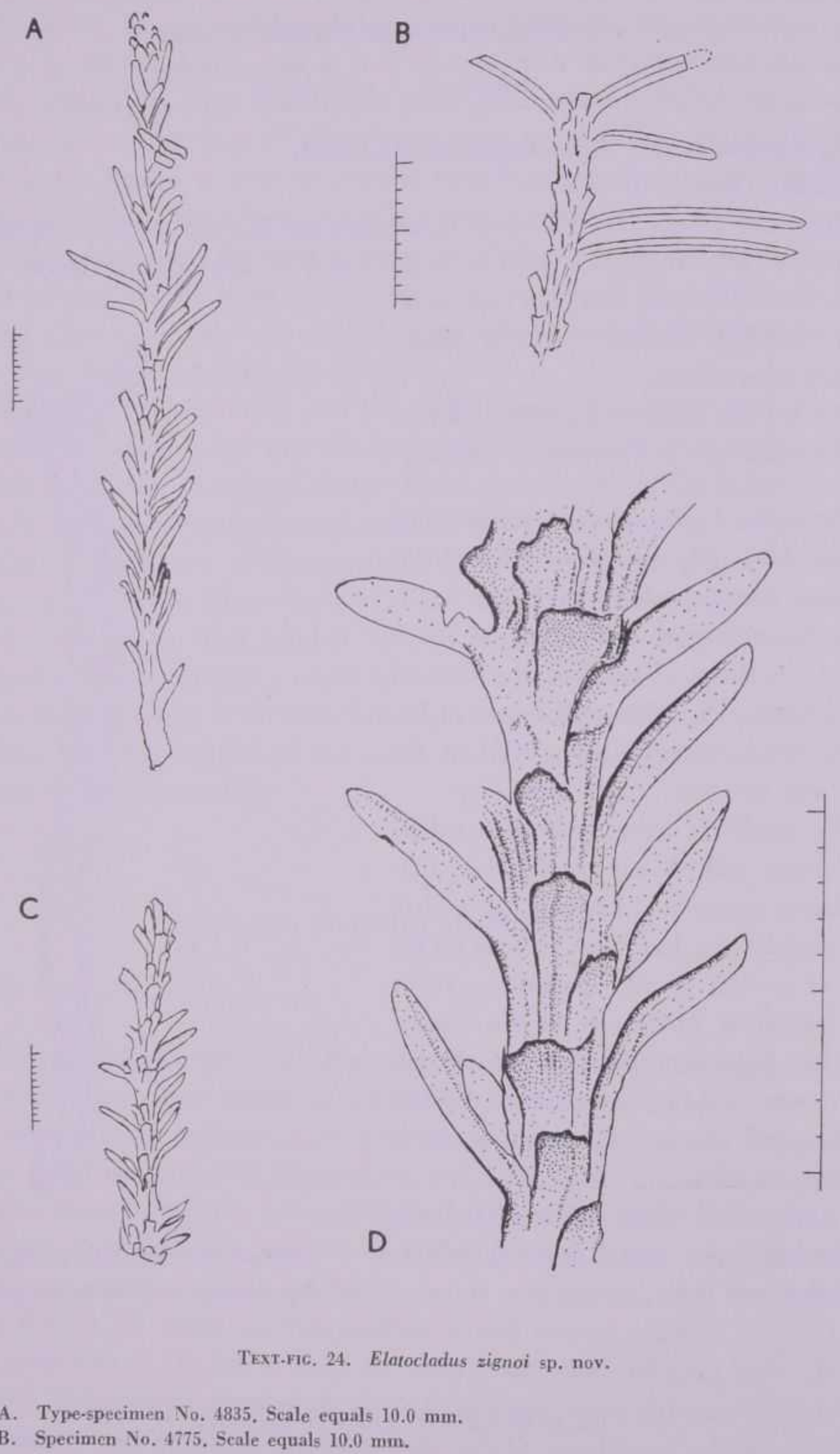


TEXT-FIG. 23. *Elatocladus veronensis* sp. nov. Type-specimen No. 5278. Scale equals 10.0 mm.

ELATOCLADUS ZIGNOI sp. nov.

Plate VI, figs. 4-5. - Text-fig. 24 A-D.

Type-specimen: De Zigno Collection No. 4835 (and counterpart No. 4833).
Localities: Roverè di Velo (Type-specimen); Rotzo; Val d'Assa.
Diagnosis: Sterile conifer shoot; (branching not known). Leaves arranged in a spiral of about 2/9; leaf arising without constriction from a decurrent leaf-base; free part



TEXT-FIG. 24. *Elatocladus zignoi* sp. nov.

A. Type-specimen No. 4835. Scale equals 10.0 mm.
B. Specimen No. 4775. Scale equals 10.0 mm.
C. Specimen No. 4843. Scale equals 10.0 mm.
D. Part of specimen No. 4843 enlarged to show leaf-form and decurrent leaf-bases. Scale equals 10.0 mm.

of leaf spreading at an angle of about 45° to the stem, 6.0 - 12.0 mm. long, 1.5 mm. wide and 1.0 mm. thick; apex obtuse.

The species is named after De Zigno.

Description: None of the specimens to which I have assigned the name *Elatocladus zignoi* has cuticle. All of them however agree closely in their external morphology. The following are regarded as being *E. zignoi*:

4766 - *Taxites* - Roverè di Velo
4775 - *Taxites* - Rotzo
4831 - *Palissya Williamsoni*? Brongn. - Val d'Assa
4832 - Roverè di Velo
4833 & counterpart 4835 - Roverè di Velo
4839 - Roverè di Velo
4843 & counterparts 4765 and 4849 - *Palissya* - Roverè di Velo
4847 - Roverè di Velo

The leaves of this species are only slightly broader than thick, and the free parts arise abruptly, without constriction, from decurrent leaf-bases. The midrib is not conspicuous in any specimen, and the longitudinal depressions in the imprint of the leaves in the rock-matrix are regarded as indicating that the leaves had marked lateral margins.

Specimen No. 4831 has an interesting label which refers to its locality and vertical position in the « grey limestones », as well as to its uncertain identification. The label reads « *Palissya Williamsonis?* Brongn. Strati inferiori dell'oolite della Val d'Assa a 50 metri al di sotto dello strato a Cicadee. Determinazione di questo indiavolato esemplare molto incerto (1854) ». There is only one other reference, also on a specimen label, to the presence of two plant-bearing strata in the Val d'Assa. This is an important point since it may mean that one is dealing with two distinct floras. However, for the moment, I will leave consideration of this possibility and discuss it in a later publication.

Comparison: The shoots of *Elatocladus zignoi* are very like some of the vegetative parts of cone-bearing shoots referred to *Elatides williamsoni* (Brongn.) Seward [Harris, 22]. The shoots also resemble those figured by Goeppert [16; Taf. 48, figs. 1 and 2] as *Palissya braunii* Endlicher. However, since the Italian specimens do not bear cones, I prefer to describe them under another name.

RIASSUNTO

La classica collezione di piante fossili dei calcari grigi del Veneto del Barone Achille De Zigno forma la base di una nuova serie di pubblicazioni della quale questa contribuzione rappresenta la prima parte.

Queste piante fossili, conservate nel museo dell'Istituto Geologico dell'Università di Padova, furono raccolte dal De Zigno e da lui descritte ed illustrate nei due volumi del magistrale lavoro intitolato *Flora fossilis formationis oolithicae* (1856-85) ed in altre varie pubblicazioni di circa lo stesso periodo.

La flora fossile, proveniente da roccie giurassiche, era conosciuta in un primo tempo soltanto a Rotzo nei Sette Comuni vicentini, e fu scoperta nel 1764, secondo l'Abate Del Pozzo. Altri autori, anche più tardi, riferirono sui giacimenti di piante fossili di Rotzo, ma toccò al De Zigno di pubblicare le descrizioni e le illustrazioni, complete e scientifiche, delle piante, durante il periodo 1852-91 quando egli si occupava dello studio della flora.

Alle ricerche pubblicate si aggiungono i manoscritti inediti del De Zigno, che ancora esistono nella biblioteca dell'Istituto Geologico di Padova. Alla sua morte il Barone stava preparando attivamente il terzo ed ultimo volume della sopradetta *Flora fossilis*... il quale non fu mai pubblicato. Quest'ultimo volume avrebbe contenuto le descrizioni ed illustrazioni delle conifere fossili dei calcari grigi.

Una revisione parziale della *Flora fossilis*... fu pubblicata nel 1913 dalla Grandori sotto il titolo *La Flora dei Calcari Grigi del Veneto*, dopo di che gli esemplari del De Zigno non furono esaminati da altre persone. Grazie alla cortesia del Prof. Giambattista Dal Piaz ho potuto approfittare di un esame minuzioso di detti esemplari per i miei nuovi studi.

L'interesse principale della flora fossile dei calcari grigi risiede nella sua età geologica. Essa fu ritenuta contemporanea delle flore fossili delle roccie giurassiche (oolite inferiore) del Yorkshire nella Gran Bretagna dal De Zigno, che per errore attribuì alcune conchiglie fossili, provenienti dagli stessi strati, a tipi oolitici. Opinioni recenti, che non sembra si possano discutere, a causa dei ritrovamenti di faune fossili associate, collocano la flora con la facies più alta del Lias medio (Charmoutiano) nel Domeriano e in contatto diretto con la base del Lias superiore (Toarciano), cioè nella zona a *Paltopleuroceras spinatum*. Per questa ragione, dunque, uno studio della flora è tanto importante poichè il complesso di specie ci dà notizia, forse la sola, di una fase della storia della flora mondiale.

E' stato compiuto un esame petrografico di piccoli esemplari di due tipi delle roccie più comuni - il tipo grigioscuro di Rotzo e della Val d'Assa, ed il tipo gialla-tro dei

Pernigotti. Ambedue le roccie sono calcari a grana piccolissima e questo fattore contribuisce all'ottimo stato di conservazione e adeguata grandezza di alcuni dei fossili. La roccia raccolta ai Pernigotti è eccezionale per il fatto di avere grana più piccola di ogni altra roccia comparabile. Inoltre, ambedue i calcari hanno subito poca ricristallizzazione, il che ha pure favorito la conservazione organica. E' probabile che essi si siano originati da fango aragonitico, il quale ricristallizzò al tempo di litificazione della roccia senza un aumento nelle dimensioni dei cristalli. Il carattere petrografico indica un ambiente come quello dei mari intorno alle Bahamas ai tempi nostri dove l'aragonite, minutamente cristallina, va precipitando dalle acque oceaniche in aree di acque poco profonde fiancheggiate da rizoforee. Nessuna prova irrefutabile di un ambiente marino esiste però nei due esemplari esaminati e le conchiglie a pareti sottili, che sono presenti in ambedue i casi, sono forse di origine non-marina. Chiaramente nel caso del calcare grigioscuro, che ha un contenuto organico povero, l'ambiente era stagnante, ma l'altro calcare mostra con evidenza d'essersi formato sotto l'influenza di una leggera azione di corrente.

In numerosi casi le piante fossili conservano ancora traccie del materiale originario delle piante. La cuticola, molto resistente alla decomposizione, è stata preparata da tali esemplari in modo che un esame microscopico mostri i dettagli nella distribuzione delle cellule epidermiche e degli stomi. Piccoli frammenti del materiale organico di una pianta fossile sono sottoposti all'azione di clorato di potassa con acido nitrico concentrato per dodici-ventiquattro ore. Il materiale viene indi lavato con cura e sottoposto all'azione di una soluzione d'ammoniaca diluita finchè tutta la materia organica sia stata estratta, indi le piccole scaglie fragili di cuticola vengono montate in sciroppo Karo. Si deve osservare che questo sciroppo è molto utile per montare le scaglie di cuticola perchè con esso la disidratazione non è necessaria, come quando si usa il balsamo del Canadà. Inoltre gli zuccheri di cui è costituito non cristallizzano quando si solidifica.

Giacchè esistono poche notizie sulle conifere fossili dei calcari grigi ho cominciato i miei studi con una ricerca su questo gruppo di piante, attingendo liberamente dai manoscritti inediti del De Zigno.

Per semplicità le conifere sono divise in quattro forme; forme a foglie crasse, disposte a spirale, la cui nervatura non è conosciuta (Forme-generi *Brachyphyllum*, *Pagiophyllum* e *Dactylethrophyllum*), forme con foglie ad una sola nervatura (Forma-genere *Elatocladus sensu lato*), e forme con foglie a parecchie nervature (Forma-genere *Podozamites sensu lato*). Per ora sono descritti solamente i primi quattro generi, e dopo un ulteriore periodo di studio le forme con foglie a parecchie nervature verranno descritte nella seconda parte delle presenti ricerche. Inoltre gli organi riproduttori verranno illustrati separatamente più tardi, perchè non c'è prova della loro appartenenza ad alcun esemplare già esaminato.

I due generi *Brachyphyllum* e *Pagiophyllum* sono molto simili e differiscono soltanto nella forma della foglia. Nel *Brachyphyllum* la parte libera della foglia è sempre corta e raccolta, e non supera la larghezza della base della foglia, mentre nel *Pagiophyllum* la parte libera è più larga e la sua lunghezza supera sempre la larghezza della base della foglia. Tuttavia c'è talvolta una certa sovrapposizione fra forme estreme dei due generi e non è sempre facile differenziarle. Non c'è neppure alcuna caratteristica della cuticola

che le possa separare. In generale, però, gli esemplari italiani rientrano chiaramente nell'uno o nell'altro gruppo. I presenti studi mostrano che cinque specie del *Brachyphyllum* e sette specie del *Pagiophyllum* si presentano nella flora dei calcari grigi. Tutte le specie del *Brachyphyllum* e sei specie del *Pagiophyllum* sono nuove per la scienza. La settima specie del *Pagiophyllum* (*P. rotzoanum*) è stata già descritta dal MASSALONGO e dal SAPORTA. Tutte le specie sono distinte dalle altre scoperte nelle roccie giurassiche britanniche, e non si è potuto identificarle con forme provenienti dagli altri strati giurassici dell'Europa e dell'India.

La nuova forma-genere *Dactylethrophyllum* è stata istituita per includere un ramoscello che non si può attribuire al *Brachyphyllum* o al *Pagiophyllum*. Purtroppo le strutture degli organi riproduttori sono sconosciute, ma tutti i suoi tratti caratteristici indicano che si trattava di una conifera. Si distingue tanto dal *Brachyphyllum* quanto dal *Pagiophyllum* per la forma esterna delle sue foglie e la struttura della sua cuticola. Le foglie sono tanto lunghe quanto larghe, tipicamente più lunghe e si estendono sempre al di là della base della foglia. In sezione trasversale la foglia è circolare o ampiamente biconvessa, senza orli angolosi, e non mostra alcun appiattimento dorsoventrale. Inoltre il *Dactylethrophyllum* presenta gli stomi disseminati a caso su tutta la superficie della foglia e non ordinati in file longitudinali come negli altri due generi. Una sola specie del *Dactylethrophyllum* è stata scoperta.

In senso più ampio la forma-genere *Elatocladus* include ramoscelli sterili di conifera con foglie lineari ad una sola nervatura disposte a spirale o a pseudodistico. Sfortunatamente non è stato possibile preparare la cuticola per fare un esame microscopico degli esemplari dell'*Elatocladus* e così si sono dovute definire le due specie presenti solamente tramite la morfologia esterna.

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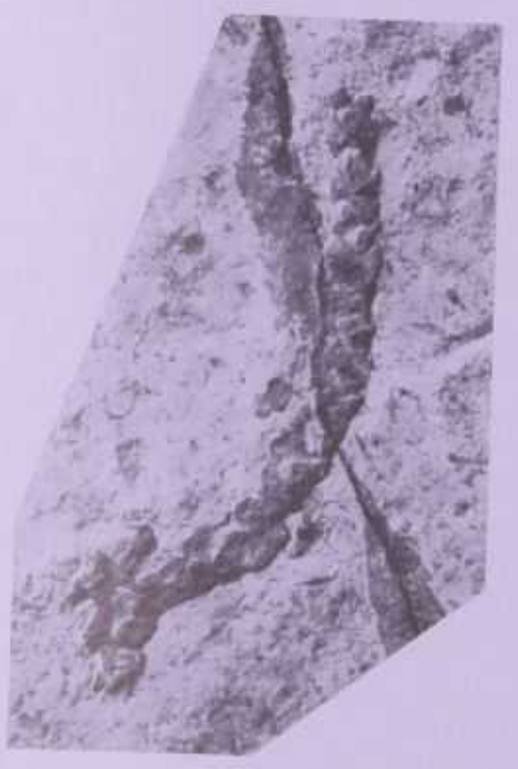

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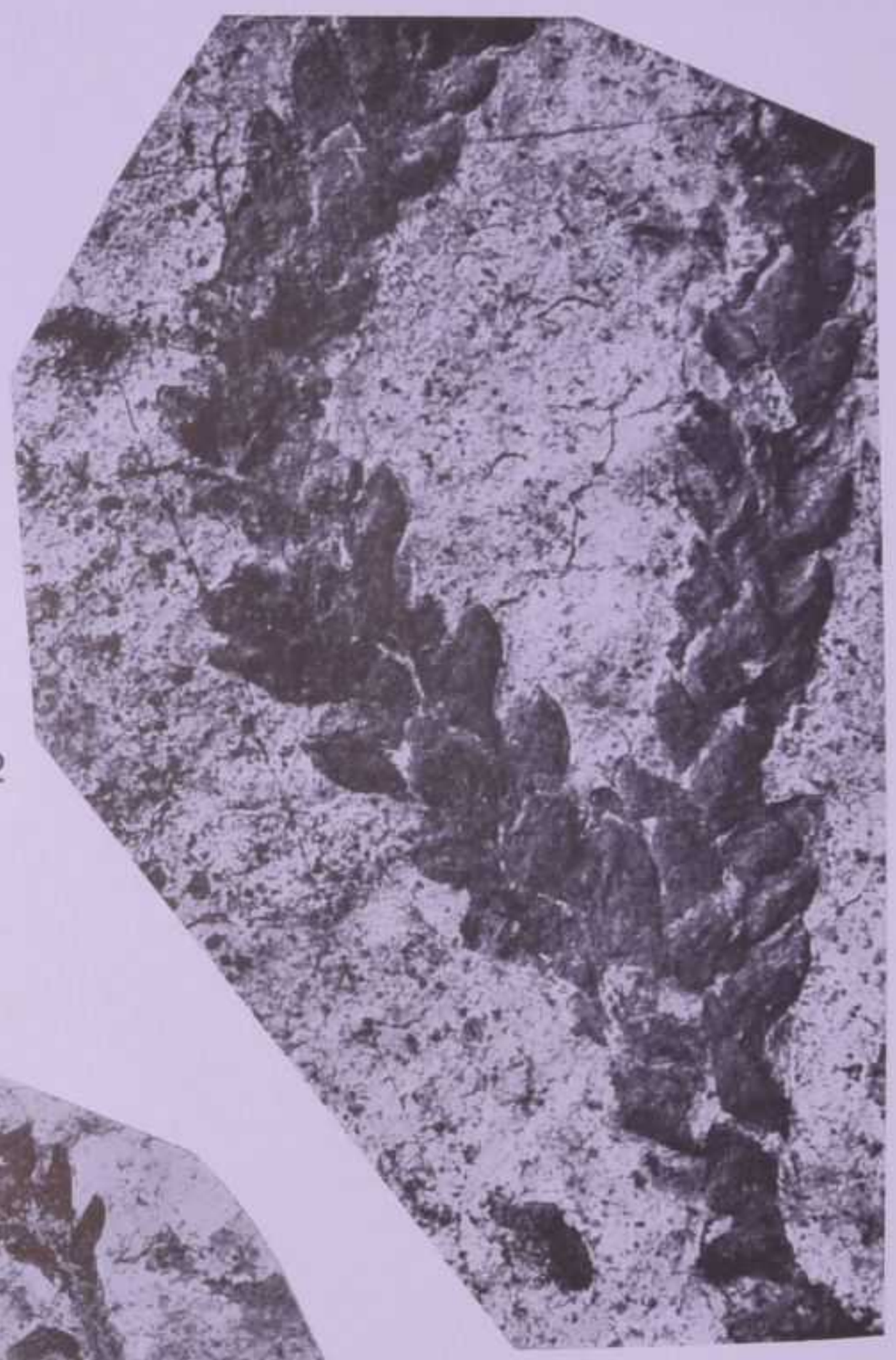

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