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PALYNOLOGY OF CORE SAMPLES OF PALEOZOIC SEDIMENTS FROM BENEATH THE COASTAL PLAIN OF EARLY COUNTY, GEORGIA

by
Robert E. McLaughlin

THE GEOLOGICAL SURVEY OF GEORGIA
DEPARTMENT OF MINES, MINING AND GEOLOGY

Jesse H. Auvil, Jr.
State Geologist and Director

ATLANTA

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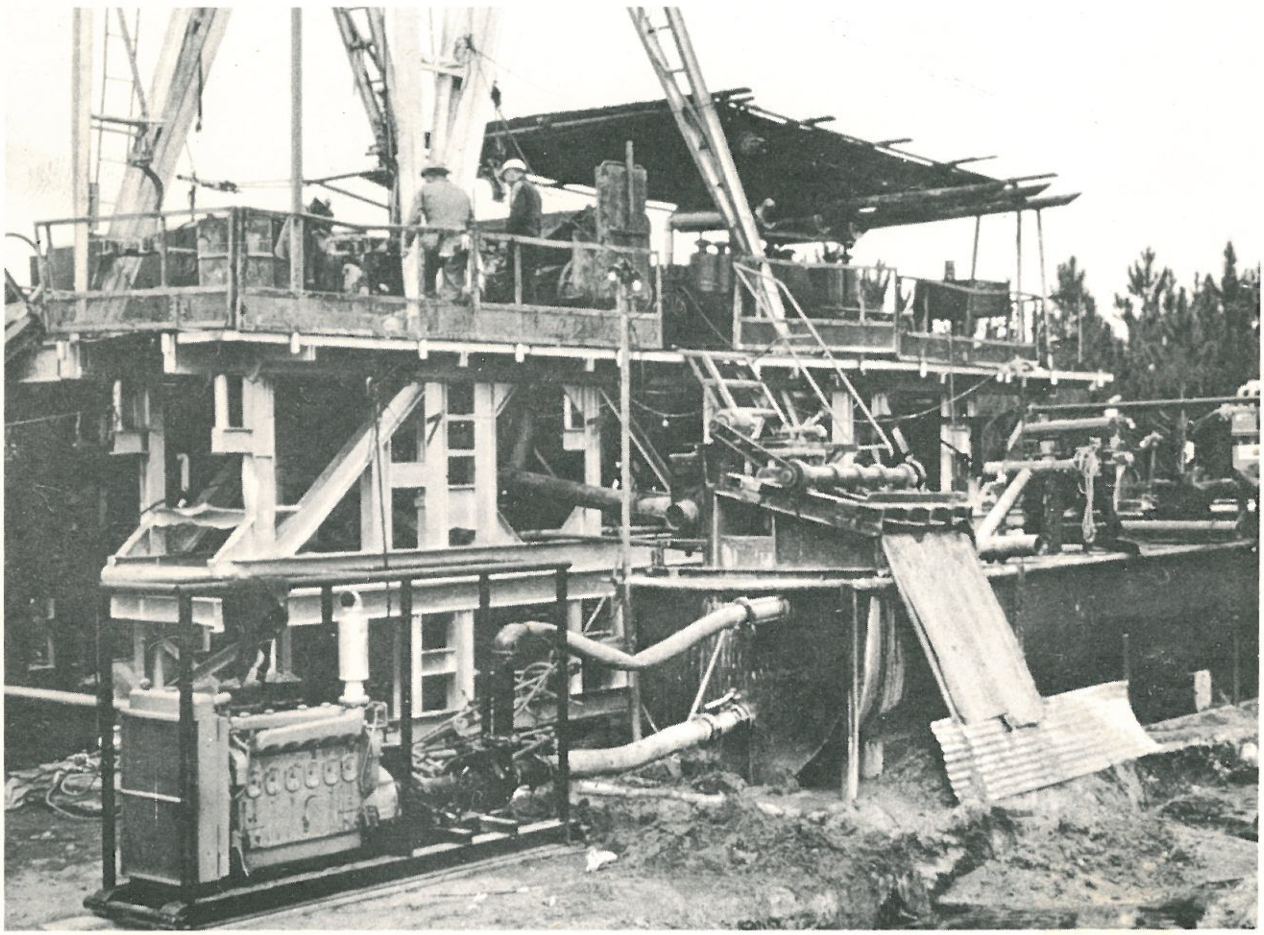

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PALYNOLOGY OF CORE SAMPLES OF PALEOZOIC SEDIMENTS FROM BENEATH THE COASTAL PLAIN OF EARLY COUNTY, GEORGIA

ABSTRACT

Microscopic study of an alternating dark siltstone or shale-quartzose sandstone section of core from an oil test between 7356 feet and 7570 feet beneath lower Coastal Plain sediments in Early County, Georgia, provides palynological and other evidence to support a Devonian age assignment to that part of the core, excepting, perhaps, the basal 64 feet.

Plant stem fragments recovered previously at a depth of 7402 feet and additional megascopic material, within two feet below the first noted, are described and illustrated. These fragments compare favorably with remains of other plants of Devonian age comprising the first well-documented land flora in Earth history.

Selected microfossils demonstrating the range of morphology and systematic diversity are figured and briefly described. These include several plant sporomorph taxa and hystrichospheres (acritarchs). Confirmation of paleogeographic inferences suggested by the occurrence of such material of this age and location is among the chief objectives in the continuing study.

INTRODUCTION

Megascopically visible plant remains (see Plate I, inset, Appendix) were discovered in the course of examining core samples (GGS 1145) obtained in 1969 from an oil test (Anderson, et. al.-Great Northern Paper Co. No. 1) drilled two miles southwest of Cedar Springs, Early County, Georgia (Fig. 1) to a depth of 7580 feet (ground level elevation is 190 feet). As a consequence, the possibility that potentially valuable stratigraphic information might be revealed through a detailed microscopic examination of the core samples prompted the investigation from which initial results are reported herein.

Previously published accounts of the deeper rocks (below 6500 feet) underlying the Coastal Plain in Early County are generally limited to lithologic description, with some geophysical interpretation, but little or no paleontologic study. Exceptions to the latter apparently led to the observations made by Mrs. Ester R. Applin (in Applin, P. L., 1951; Applin and Applin, 1964) on core material (GGS 121) recovered in 1943 from the Warren, et. al—A. C. Chandler No. 1 test (250 ft. N. and 968 ft. W. of S.E. corner of N. 1/3 of L.L. 406, L.D. 26). Swartz (1945, 1949) reported on ostracods and, more recently, Palmer (1970) described pelecypods encountered in the same GGS 121 material. As an indication of the need for more information concerning these rocks and their correlatives, these three investigators separately concluded that the part of the core section between 6995 feet and 7015 feet depths was of conflicting Late Ordovician-Early Silurian, Middle Devonian, and Early Pennsylvanian (Pottsville) ages.

Adding further to the stratigraphic uncertainty surrounding the deep sedimentary rocks of Early County, Bridge and Berdan (1952) tentatively classified the same GGS 121 interval noted above as Upper Ordovician or Silurian based on lithologic similarity to deep well rocks in Florida. J. M. Schopf, quoted by J.M. Berdan in Applin and Applin (1964), on the other hand, regarded the spores recovered from these rocks as not older than Middle Devonian.

General references containing these and other views on the chronostratigraphy and associated tectonic setting and paleogeography of the older rocks beneath the Coastal Plain are to be found in Cooke (1943), Applin, P.L. (1951), Bridge and Berdan (1952), Murray (1961), Herrick (1961, summarizing post-Paleozoic penetrations in Georgia), Herrick and Vorhis (1963), and Berdan (1964). It is abundantly clear that the solutions to many local and regional problems involving the rocks below the depths to which known marine faunas of Cretaceous age extend require much more additional data, ideally based on paleontologic information heretofore in short supply. Promising newer approaches to the solutions are indicated in the work of Andress, Cramer and Goldstein (1969), Goldstein, Cramer and Andress (1969), and Carrington (1970).

Furcron (1965) and Milton and Hurst (1965) discuss the range of uncertainties presented by the older rocks of Georgia and elsewhere under the Coastal Plain. Elucidation of these problems can lead, in turn, to improving the economic potential of the region as well as adding to present knowledge of past geologic history.

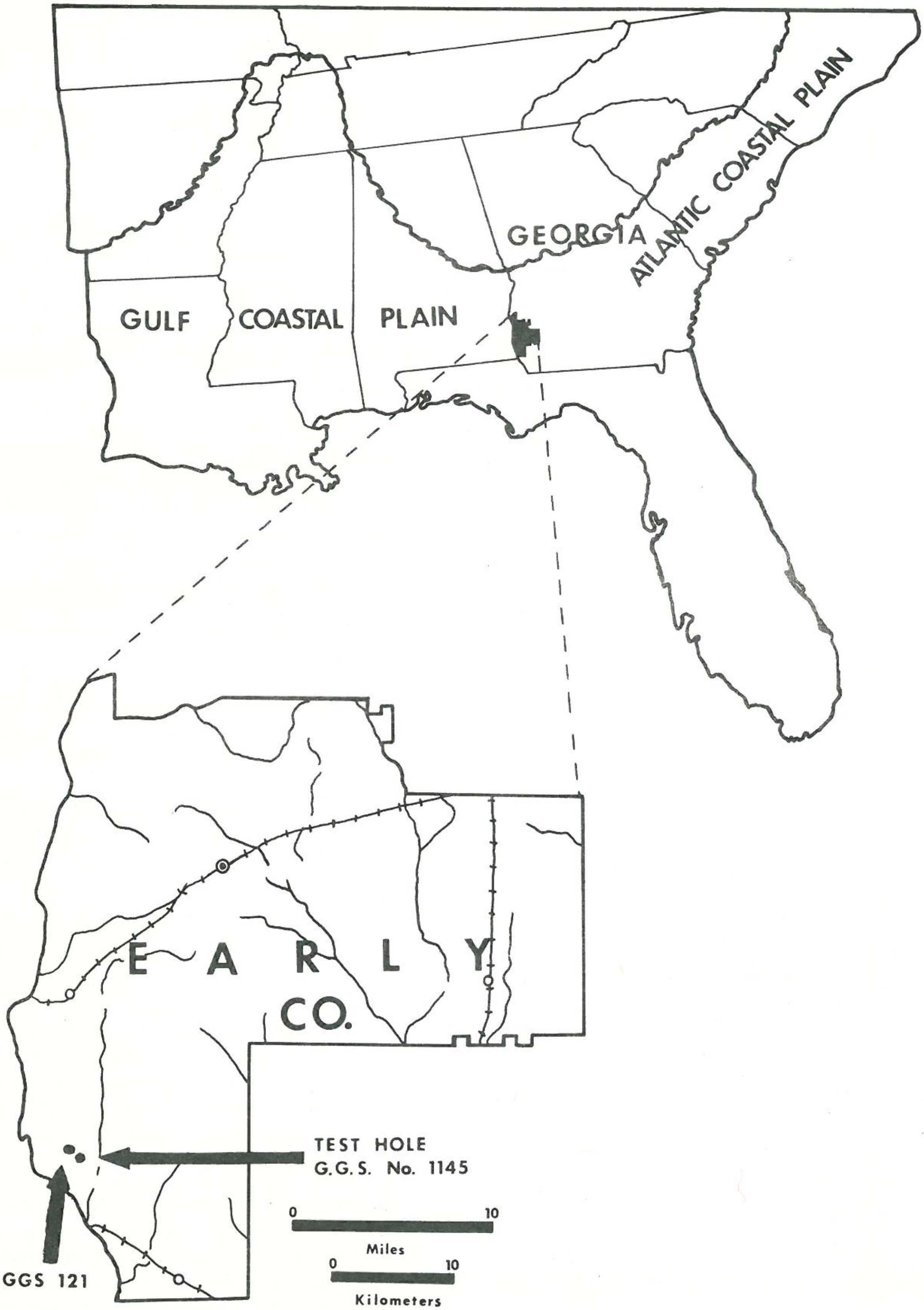

Figure 1. Location map of test hole.

ACKNOWLEDGMENTS

The assistance of Mr. Jesse H. Auvil, Jr., Director, and Mr. Sam M. Pickering, Jr., Deputy Director, Department of Mines, Mining and Geology, in initiating and conducting the investigation described herein is gratefully acknowledged. Mr. Auvil allocated financial support toward the study and, with Mr. Pickering, provided encouragement, the use of materials and facilities, and many other expressions of cooperation throughout.

Michael L. Jones, Edward C. Martin, Barry R. Wood, and Benjamin K. Bryan, Jr., graduate students, and Drs. Alan S. Heilman and G. Michael Clark, all at the University of Tennessee, materially aided in the study in a variety of ways.

Numerous colleagues have given freely of their time and professional expertise at different stages of the investigation. Notably, Dr. D. Colin McGregor, Geological Survey of Canada, Dr. William C. Elsik and Mr. Hunter Yarborough, Humble Oil and Refining Company, and Dr. William F. Von Almen, Chevron Oil Company, have contributed substantially toward the writer's conclusions regarding the age and other geological implications of the material examined.

PROCEDURES

The present report concerns the lowermost 214-foot interval of the Anderson, et. al.—Great Northern Paper Co. No. 1 test (GGS 1145), between 7356 feet and 7570 feet. The samples examined in this interval include those recovered above and below the horizon bearing the megascopic plant remains noted above. The lowermost 64 feet of the test, consisting of sandy cuttings with shale chips at the base, was not analyzed in great detail owing to the problematical nature of the material.

In addition to providing lithologic details, low-power and megascopic examination of the samples covering the interval has disclosed two sources of paleontologic information. First, adding to the best preserved plant remains at 7402 feet (Plates I and II), small plant stem impressions were observed in quartzose sandstone between 7400 feet and 7402 feet. These fragments appear similar or identical to the larger specimens and serve to extend slightly the stratigraphic range of these plant megafossils. Secondly, in the 7370 to 7418 foot interval, in all lithologies, megascopic to submegascopic, round to ovoid, carbonaceous bodies up to ¼ mm in diameter were found. These bodies are concentrated at 7370-, 7375-, 7378-, 7384-, and 7418 feet. They appear to be present also in thin sections made from larger core pieces between 7401-7402 feet. These objects are similar to enigmatic organic microfossils which have been called tasmanitoids. Notwithstanding the uncertainty of identification with which these objects are viewed at the present time, they do provide a certain amount of stratigraphic continuity across the interval.

Maceration residues containing identifiable organic material were obtained from samples representing the 7356-, 7360-, 7370-, 7378-, 7387-, 7402-, 7403-, and 7407-foot levels. Upon microscopic (high power) analysis, sporomorphs of plant origin, plant tissue fragments, hystrichospheres (acritarchs), and a number of less definitive entities were easily observed with little or no staining on slides prepared from the residues. After determining in thin section the mineralogic character of the matrix, a series of experimental tests using a variety of reagents was conducted with the following technique proving most effective:

1. Gentle crushing by mortar and pestle to a consistency of fine sand.
2. Digestion in hydrofluoric acid (approximately 50%) for 24-36 hours. This reduced the mineral fraction to less than one per cent.
3. Neutralization with distilled water followed by three rinses in 95% ethyl alcohol to remove excess water. These steps were carried out in a centrifuge.
4. Storage of residues in Cellosolve (ethylene-glycol-monoethyl-ether) to increase concentration of microfossils and to provide a direct source of material for slide preparation.

All of the samples found to be most productive were from silty shale or siltstone zones; the intervening sandstone zones yielded poor residues. A tabular summary of the general lithology of the core section studied and the stratigraphic distribution of the various types of fossil material encountered is shown in Figure 2.

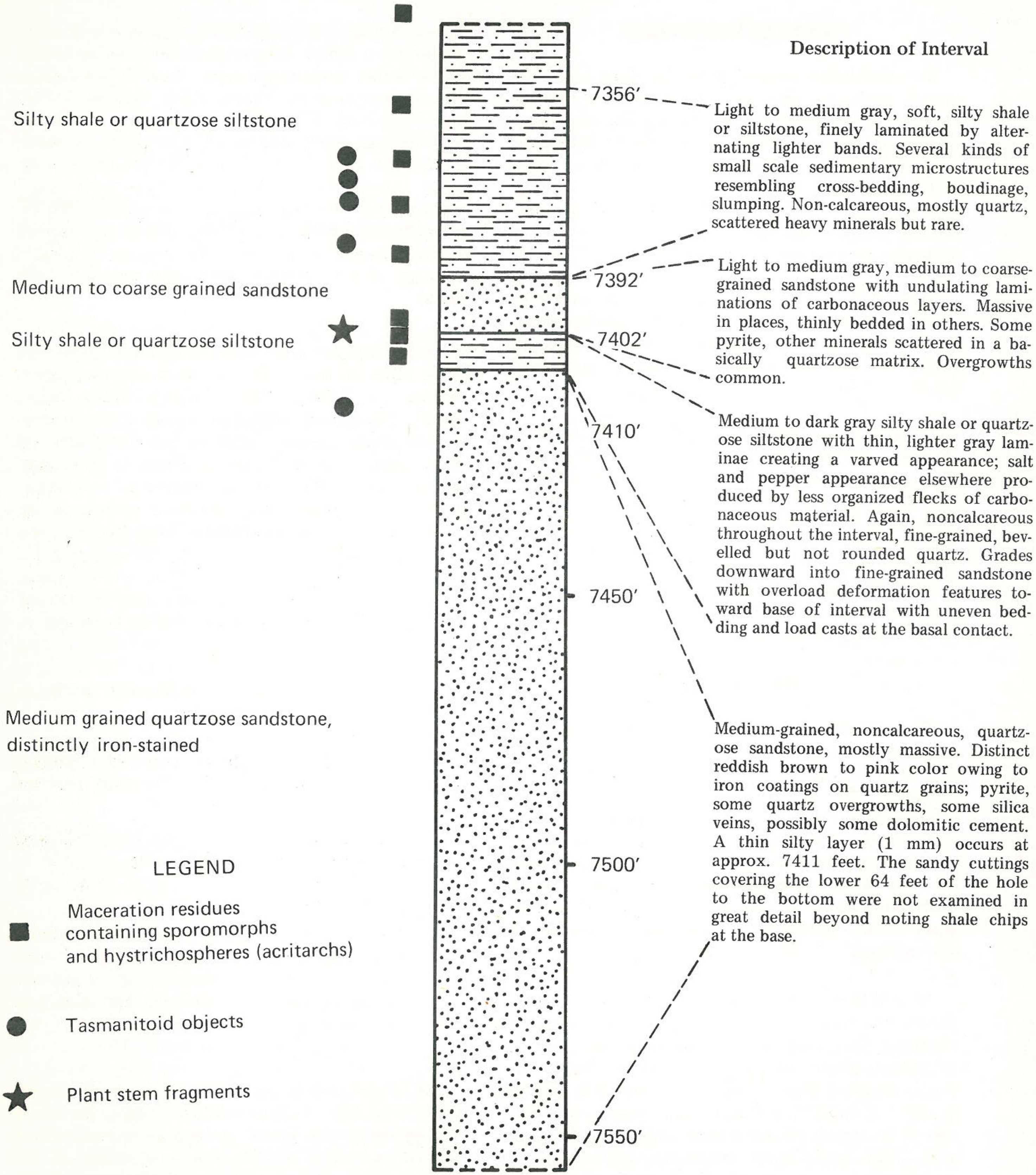

Figure 2. Partial stratigraphic section of GGS 1145.

GENERAL LITHOLOGY

In broad terms, the interval between 7356 feet and 7570 feet covered in this report can be described as consisting of alternating zones of light and dark grey silty shale or siltstone and light to medium grey, medium- to coarse-grained sandstone. However, boundaries are gradational as to texture.

Typically, the silty shale or siltstone zones are finely laminated by alternating dark and lighter bands. The dark bands represent concentrations of organic debris which is less abundant in lighter bands. The sandstone zones are commonly massive except where thin, carbonaceous layers are localized.

Mineralogically, quartz predominates the whole interval with only rare occurrences of other minerals, notably pyrite in the sandstone zones. The quartz grains are bevelled, not rounded, and commonly display overgrowths.

Beginning at 7410 feet, iron oxide coatings on the quartz grains impart a distinct reddish brown to pinkish cast to the samples that mark the top of a medium-grained quartzose sandstone zone containing some silica veins. The upper contact of this zone is marked also, perhaps significantly, by uneven bedding and load casts along with overload deformational features at and near the base of the overlying siltstone zone.

Small scale penecontemporaneous sedimentary microstructures such as cross-bedding, boudinage, and slump offsets were observed in another siltstone zone beginning at 7356 feet. Some of the larger cuttings appear to bear slickenside surfaces; however, these may be drilling artifacts. Bedding plane surfaces of all core observed are essentially normal to the drill hole, indicating that the sediments are nominally flat lying. No trace of metamorphism is apparent.

Throughout the entire interval there is little evidence of interstitial mineral cement, the lithology being distinctly non-calcareous as well. The binding influence of carbonaceous matter is apparent in the parts of the section where such material constitutes a noticeable proportion of the rock.

Superficial induration and compactness exhibited by most samples is somewhat deceptive. As stated above, moderate hand crushing and a few hours digestion in hydrofluoric acid proved to be sufficient in preparing samples for the separation of plant microfossils in maceration residues.

PLANT MEGAFOSSILS

The fossils of plant stem fragments exposed on transverse fracture surfaces at the 7400-foot and 7402-foot levels are carbonized impressions of sufficient preservation detail for general diagnosis. (See Plates I and II, Appendix.)

The stem fragments measure 2½ mm in compressed diameter and range from 5mm to 8½ cm in length. Where branching can be observed, it appears to be simple and dichotomous. The main axes are perfectly straight and somewhat obscurely furrowed or ridged parallel to the sides, with up to five ridges per diameter occurring on some fragments. Transverse ridge-like markings resembling nodal areas are obscurely developed in some pieces. However, these may have been produced by compression.

Irregularly disposed spinose, possibly falcate, lateral emergences are developed in opposite to subopposite phyllotaxy along the sides of the stems. All of the parts are vegetative in function with none bearing recognizable reproductive structures.

All of the material observed at both levels is very likely from a single taxon, judging from the fact that the range of variation among the fragments is very small. From the size of the fragments it seems reasonable to conclude that the original plant was small in size, possibly herbaceous in habit. This plant grew on a terrestrial substrate at no great distance from the site of deposition. Distance of transportation is based on the degree of preservation exhibited by the specimens.

Positive identification and full taxonomic description will require comparison with other material from contemporaneous forms. However, the gross morphology displayed by these fossils is characteristic of some members of the psilophytalean complex *sensu lato* of nearly worldwide distribution during the Devonian Period. These plants, described and discussed by paleobotanists over the past one hundred years or more, as for example, by Scott (1920, 1923, 1924), Arber (1921), Seward (1933), Andrews (1947), Arnold

(1947), and Darrah (1960), among others, constitute the first diversified land flora of Earth. Elements of this Devonian flora have been found in England, Scotland, Wales, France, Germany, Belgium, Norway, Russia, Czechoslovakia, China, Australia, North America (Canada, New York, Wyoming), South Africa, Spitsbergen, and Bear Island.

The present report does not include further descriptive detail of taxonomic diagnosis of the round to ovoid carbonaceous objects encountered in the upper 48 feet of the section of GGS 1145 examined. Study of comparative material will be required to ascertain identification with similar forms, such as the tasmanitoids previously mentioned.

MICROFOSSILS

The microfossils present in the section of GGS 1145 described in this report are numerous both in variety and numbers of individuals. The greatest concentration occurs, as previously noted, in siltstone zones. Included in this category of fossil remains are:

1. tissue fragments;
2. hystrichospheres (or, more properly, acritarchs) (Downie, Evitt and Sarjeant, 1963);
3. sporomorphs (microspores or, more properly, miospores and isospores);
4. possibly smaller tasmanitoids (as opposed to the term, tasmantids, which suggests established identity) below the megascopic size range noted previously.

The majority, if not all, of the material examined is of plant origin and has been altered little beyond the original degradation state at the time of deposition.

It is believed that the assemblage presented here includes the dominant forms characterizing the stratigraphic interval in question. As such, these microfossils will serve as biostratigraphic reference guides as the project is expanded.

The microfossil taxa illustrated include positive or, as yet, uncertain form genera. Other, less numerous forms seen in this material but not illustrated as yet, possibly include the following: *Calamospora*, *Zonotriletes*, *Zonaletes*, *Archaeozonotriletes*, *Hymenozonotriletes*, *Dictyotriletes*, *Cirratriradites*, *Acanthotriletes*, *Apiculatisporites*, *Raistrickia*, *Reinschospora*, and some with distinct selaginelloid characteristics.

Noted among the plant tissue fragments are some with apparent (resin?) ducts, commonly bordered by rings of cells (see Plate III, A, and Plate IV, A). This feature is a distinctive gymnosperm characteristic and bits of scalariform tracheid tissue (Plate IV, B) were derived also from plants of terrestrial habit.

Formal taxonomic description of the microfossils will be provided in later accounts of this investigation. It lies within the scope of the present report to illustrate and describe the variety of forms only in general terms and to make a time-stratigraphic assessment of the overall assemblage on the basis of present understanding of the geologic range of forms possessing the features shown.

DISCUSSION OF PALYNOLOGICAL RESULTS

Despite stratigraphic gaps and the paucity of information available on the occurrence of plant microfossils in the older rocks of the United States portion of the North American section, a number of workers elsewhere throughout the world (especially, see review papers and others by Naumova, 1953; Hoffmeister, Staplin and Malloy, 1955; Kedo, 1955, 1957; Luber, 1955; McGregor, 1960, 1961, 1964; Winslow, 1962; Balme and Hassell, 1962; Vigran, 1964; Wray, 1964; Allen, 1965; Chaloner and Streel, 1966; McGregor and Owens, 1966; Chaloner, 1967; Owens and Streel, 1967; Mortimer, 1967; Richardson, 1967; Menendez and de Baldis, 1967; Brito, 1967; Grignani, 1967; Daemon, Quadros and de Silva, 1967) have provided a basis for establishing definite trends in the appearance of plant microfossils from Late Precambrian time to the origin and development of a diverse and widespread land flora by the Middle Devonian, at least.

Surveying this literature and judging the combined morphological aspect of the Early County material by comparison, the following observations can be made:

1. The presence of the acritarch genus *Veryhachium* and, especially, the acanthomorphic form *Baltisphaeridium* indicates a pre-Carboniferous age for this portion of the core section with a further restriction to the Devonian Period strongly suggested.

2. The presence of at least some curvaturae-bearing retusoid forms and at least one sporomorph with what appears to be radially directed ribs points to a Devonian age.
3. The more complex ornamentation demonstrated in particular by the spinose forms is more characteristic of Middle to Late Devonian microfloras.
4. Saccate and/or zonate forms comparable to several taxa in the assemblage were established by Emsian (late Early Devonian) (Mortimer, 1967) time. This fact and the presence of distinctive tri-radiate markings on some of the sporomorphs precludes further consideration of a pre-Devonian age.
5. The size range of the sporomorphs present and the near absence of characteristic forms associated with the well-documented coal microfloras of Carboniferous age (Kosanke, 1950, and others) together provide further evidence in support of a pre-Mississippian age determination.

Paleoecologically, two elements are present in this microflora. Despite the uncertainty of biological affinities, the acritarchs, the possible tasmanitids, and some forms conceivably referable to the "true" hystrichospheres, as that name is now reserved for satisfactorily demonstrated dinoflagellate cysts, were once part of the microplankton. Barring redeposition, an unlikely circumstance considering the fragile nature of the appendages, the presence of this element ensures a marine environment of deposition for the enclosing sedimentary matrix.

The second element is represented by the mega- and microfossil remains of plants of terrestrial growth habit. Some of this material probably reached the basin of deposition via the atmosphere; the rest was brought in by aquatic transportation. In the latter case, the detail of preservation shown by stem and tissue fragments and spinose sporomorphs argues in favor of an exposed land surface at no great distance from the site of deposition.

GENERAL CONCLUSIONS

During the time interval represented by the lowermost 200 or so feet of sediments penetrated by GGS 1145, Great Northern Paper Co. No. 1 oil test, a diverse land flora of Devonian age (probably late Early Devonian or early Middle Devonian) populated a land mass in the general area bordered by a shallow water marine basin. Remains of that flora and those of the basin microplankton were incorporated in the accumulating sediment deposited in a near-shore, low energy environment as suggested by primary sedimentary features. Neither the organic content nor the lithologic features of the deposit were altered by subsequent metamorphism which has affected other Paleozoic rocks southeast of the Valley and Ridge area extending through Northwest Georgia to Pennsylvania and Nova Scotia. Viewed paleoecologically, however, there is more than 7000 feet of stratigraphic-tectonic downward vertical displacement recorded by the presence of material of this type at this depth.

Prior to the present investigation only one other deep test report (Applin and Applin, 1964) has published comprehensive information concerning the age of the rocks at the depth represented by the present study. Earlier implications by Applin (1951) were based on well records from Houston County, Alabama and Jackson County, Florida along with the log of the Mont Warren et. al.—A.C. Chandler No. 1 well (GGS 121). Details of this log in Applin and Applin (1964) show a questionable conclusion that rocks at this depth are Lower Ordovician based apparently on electric log correlation. Controversy concerning the age of rocks higher up in the section was discussed in the opening paragraphs of the present paper. It is hoped that as the current project is expanded a more reliable basis for stratigraphic judgment will be forthcoming.

PROJECTED EXTENSION OF THE INVESTIGATION

Projected phases of the continuing study include completion of the survey of GGS 1145, analysis of additional material from other deep test cores on file with the Georgia Geological Survey, and comparison of surface and subsurface data from other studies completed, currently in progress, or planned for the future. It is anticipated that the information supplied will greatly expand the usefulness of geological methods in making determinations of age and regional relationships of the subsurface rocks of Georgia and the southeastern part of the continent. Aside from conceivable economic considerations there may well be paleogeographical implications of great value as a result.

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APPENDIX

Fossil Illustrations

Among the unidentified forms illustrated are some forms not previously reported.

PLATE I

Plant megafossil material from 7402 foot level, GGS 1145, probably of psilophytalean affinities. Inset shows core surface at 3/5 natural size.

PLATE I

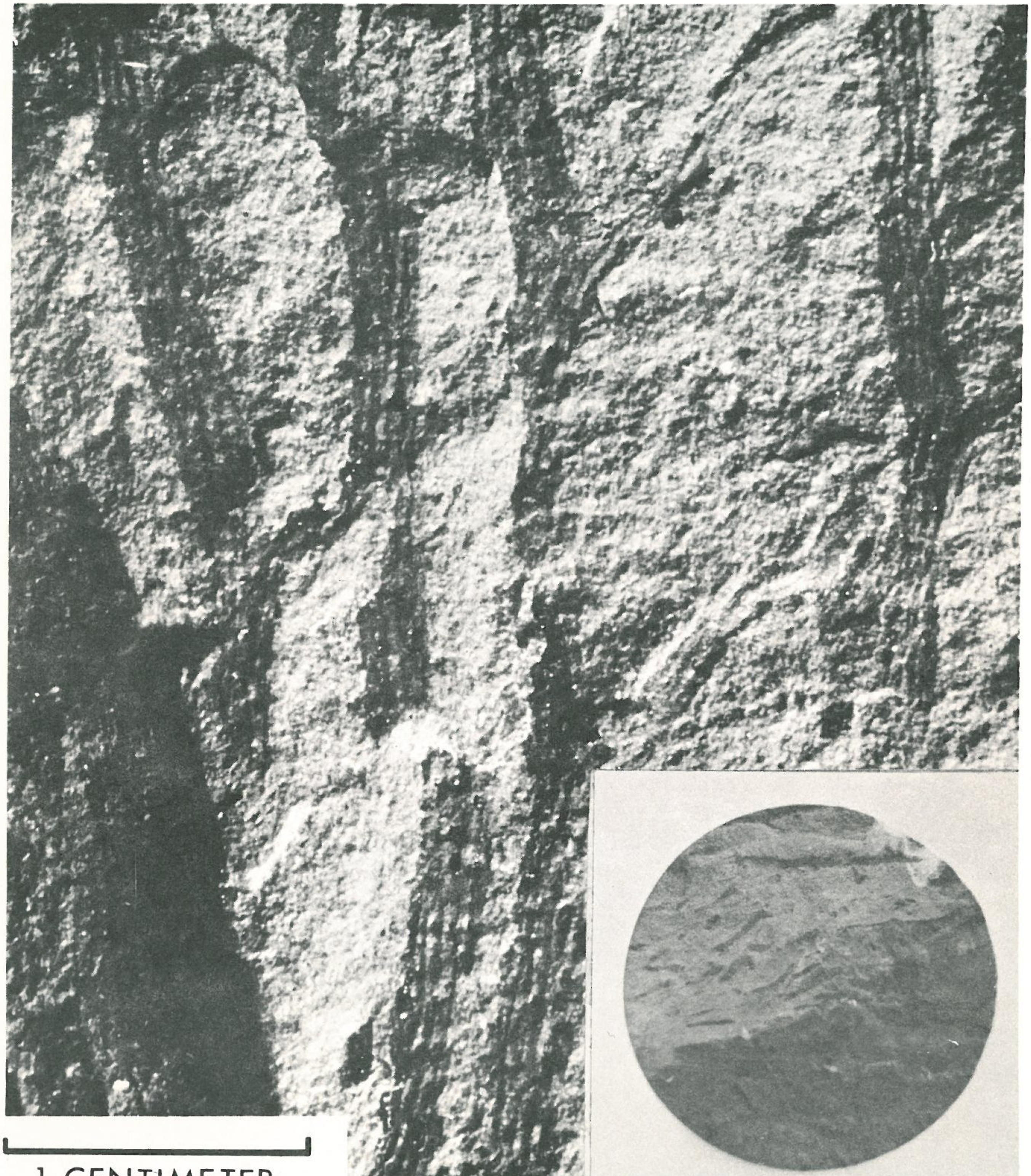


PLATE II

Another area of the core surface shown on Plate I.

PLATE 11

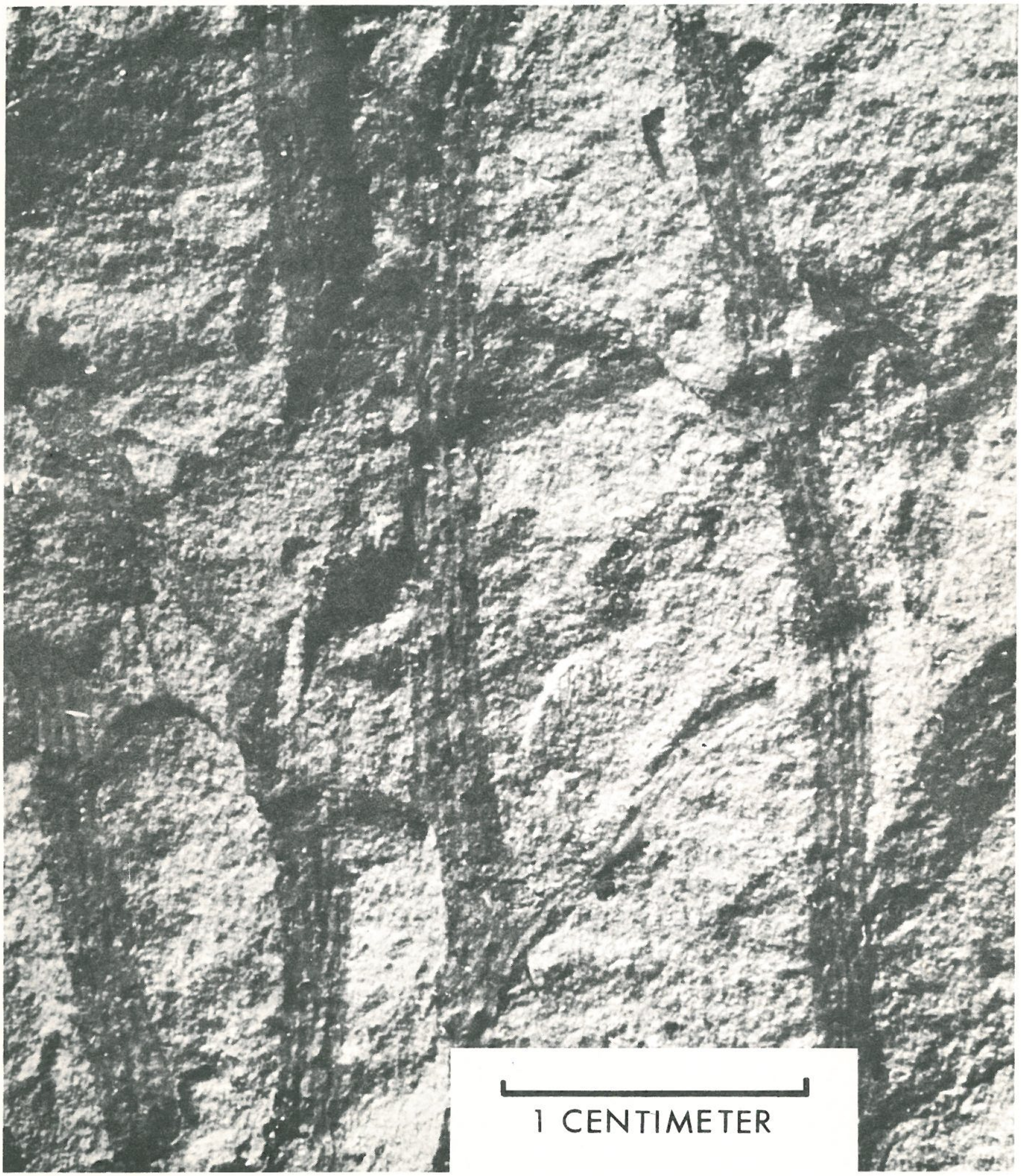


PLATE III

Typical GGS 1145 microfossil material

A. Plant tissue fragment, probably epidermal (x373)
B. Unidentified plant vascular tissue (x373)
C. Representative spores illustrating detail of preservation (x147)
D. Representative spores illustrating detail of preservation (x373)
E. Representative spores illustrating detail of preservation (x373)

PLATE III

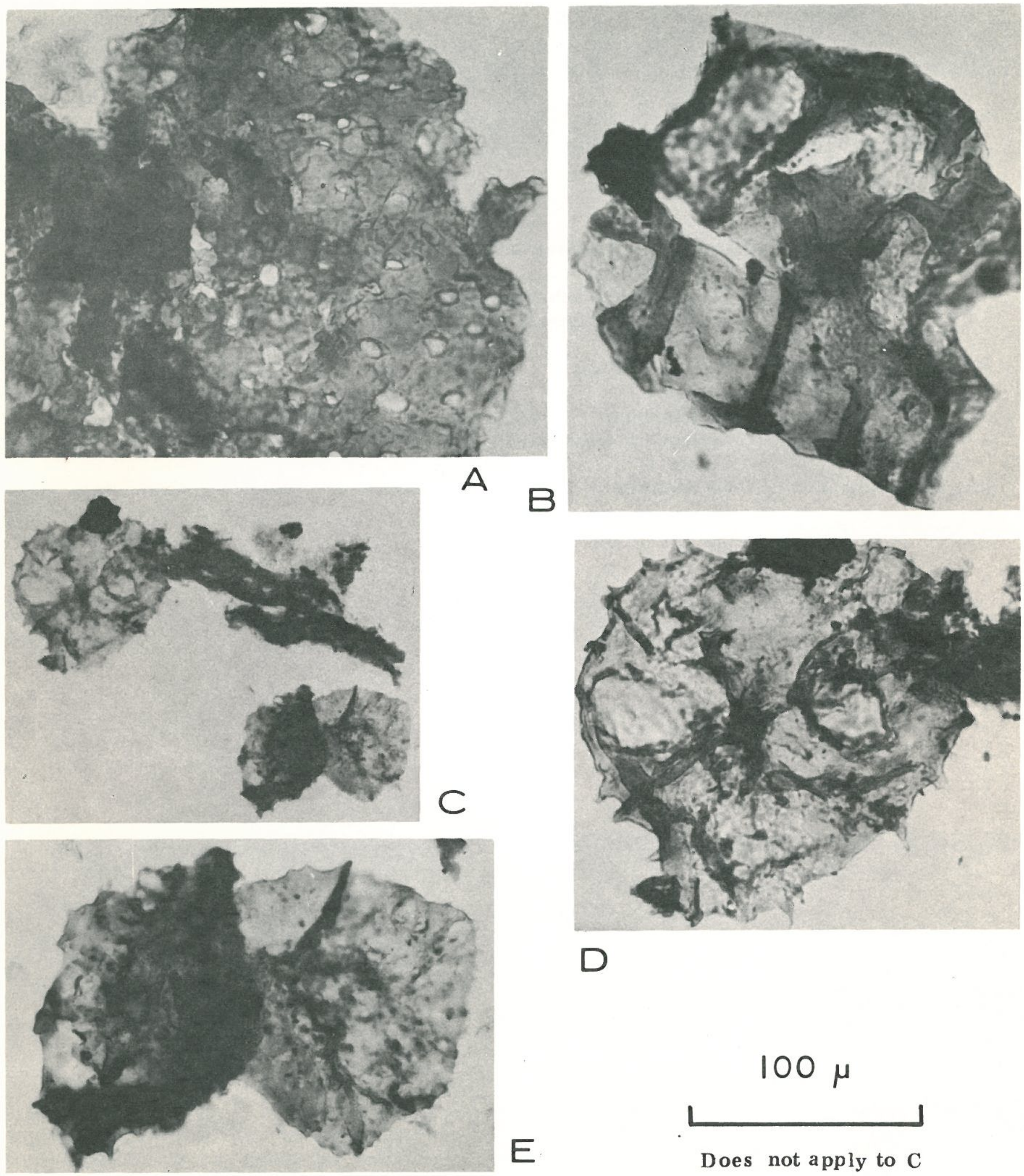


PLATE IV

Tissue fragments and representative hystrichosphere-acritarch microfossils (x540)

A. Tissue fragments showing resin (?) ducts
B. Probable scalariform tracheid fragment
C. Acritarch
D. *Baltisphaeridium*
E. Acritarch ?
F. *Veryhachium*
G. Acritarch (median and upper focus views)
H. Unidentified
I. Unidentified

PLATE IV

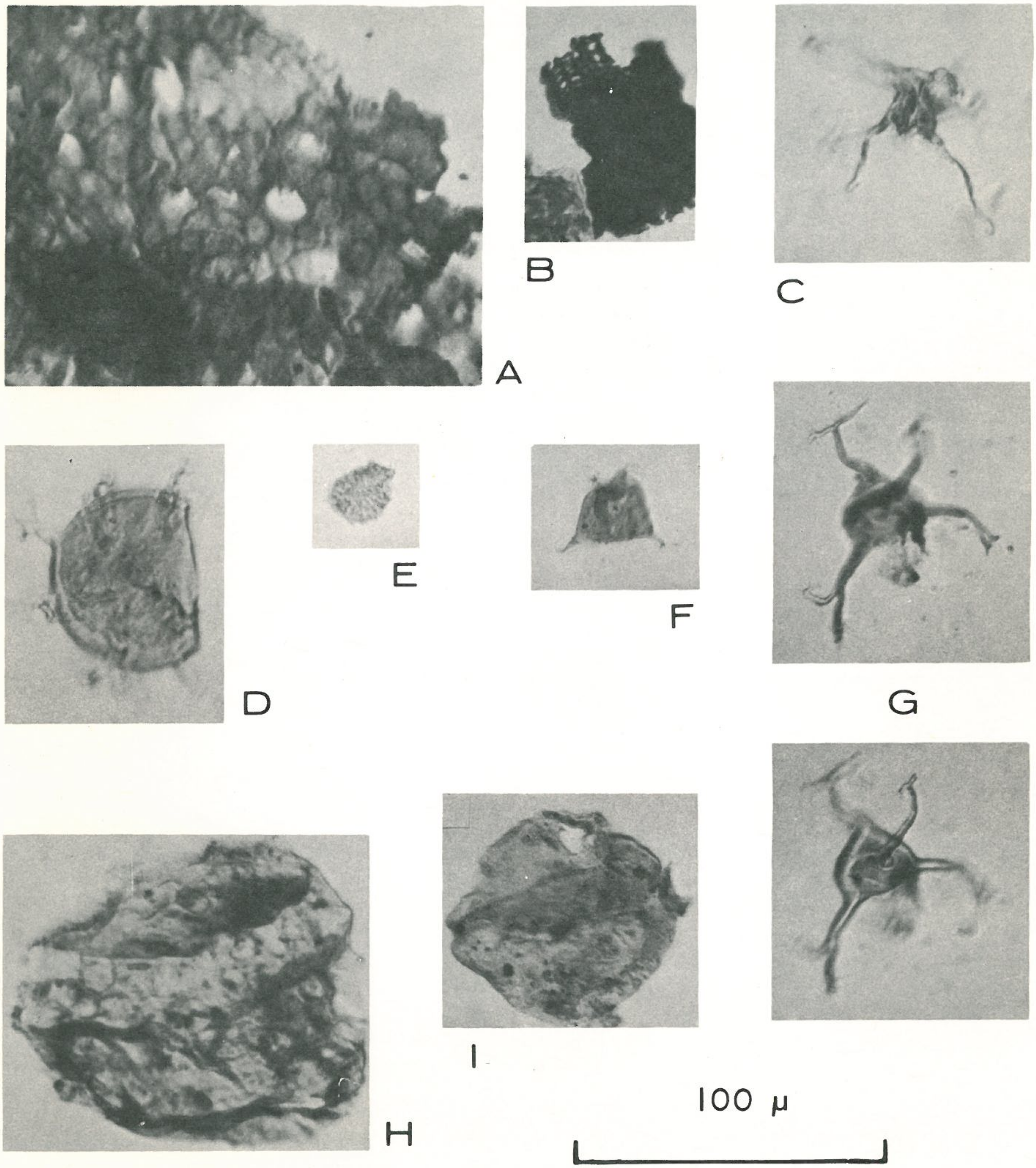
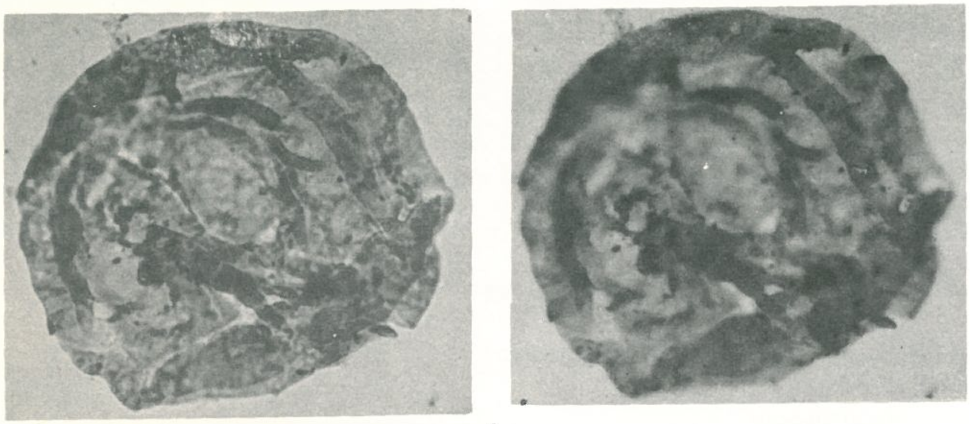


PLATE V

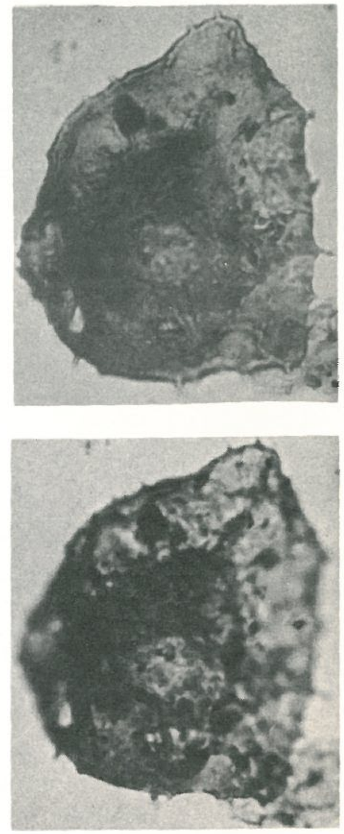
Representative plant sporomorphs (x373)

A. *Punctatisporites*
B. *Endosporites ?*
C. *Grandispora*
D. *Granulatispora* (Hoffmeister, Staplin and Malloy) or *Leiotriletes* (Naumova)
E. Unidentified

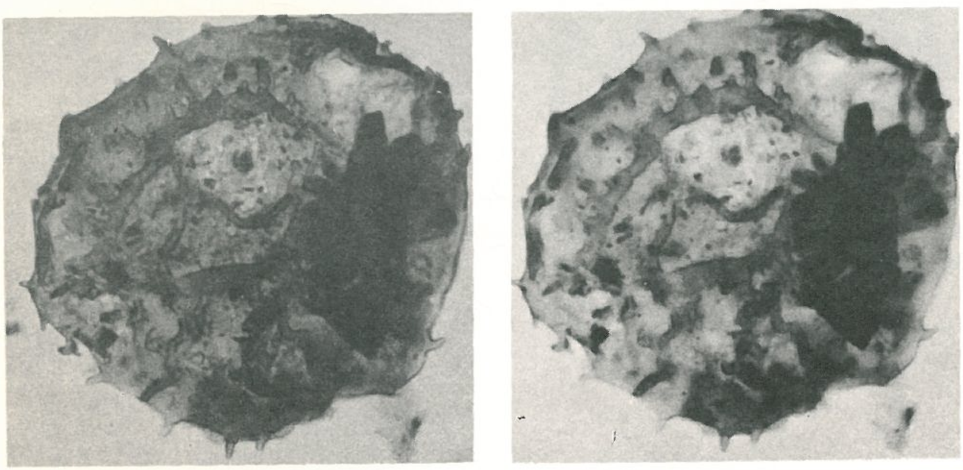
PLATE V



A

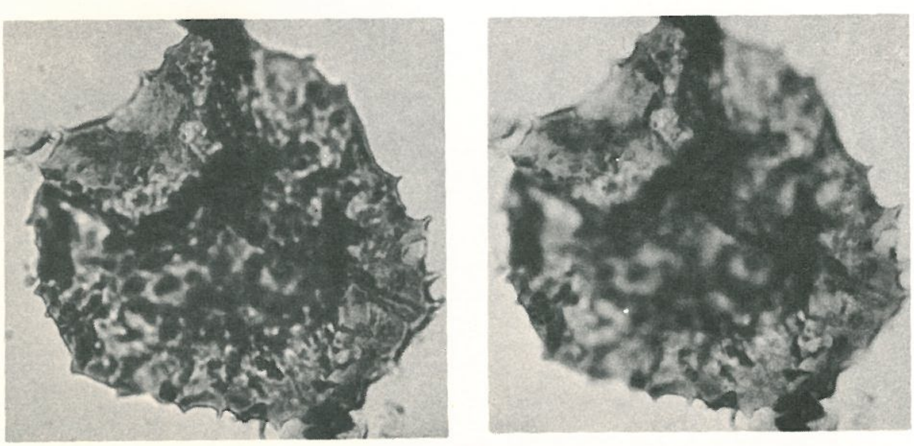


B



C

D



E

100 μ

PLATE VI

Representative plant sporomorphs (x373)

A. *Convolutispora*
B. Unidentified
C. Unidentified
D. *Ancyrospora ?* *
E. Unidentified
F. Unidentified
G. *Knoxisporites ?*
H. Unidentified

*Illustrations in Peppers and Damberger (1969) and McGregor (1960) suggest this genus or, possibly *Hystrichosporites;* however, spinose appendage features have not been confirmed.

PLATE VI

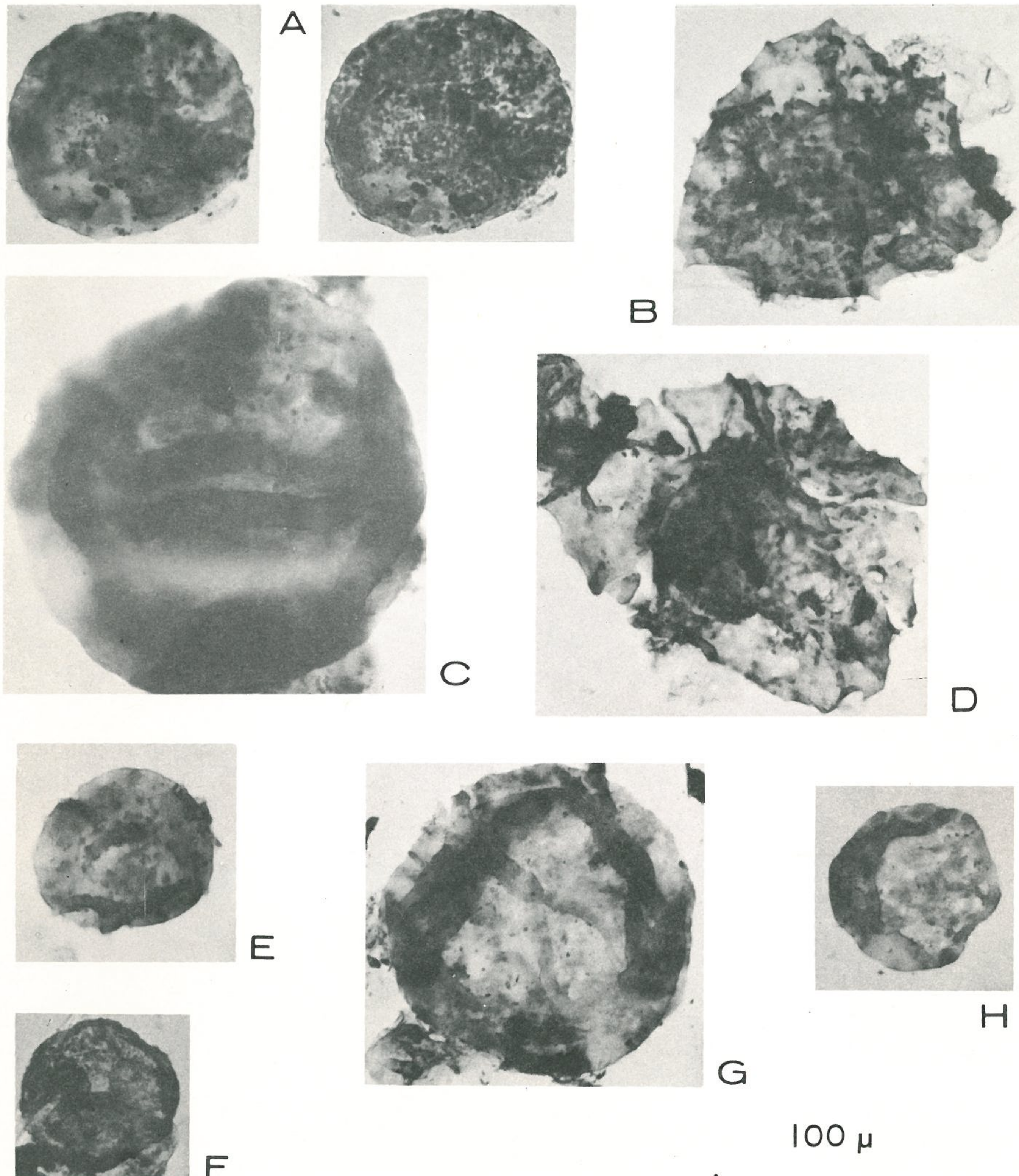


PLATE VII

Fossil Illustrations (x540)

A.	Unidentified
B.	Unidentified
C.	*Acinosporites* ?
D.	*Apiculiretusispora* ?
E.	Unidentified
F.	Unidentified
G.	Unidentified
H.	*Emphanisporites* ?
I.	Unidentified

PLATE VII

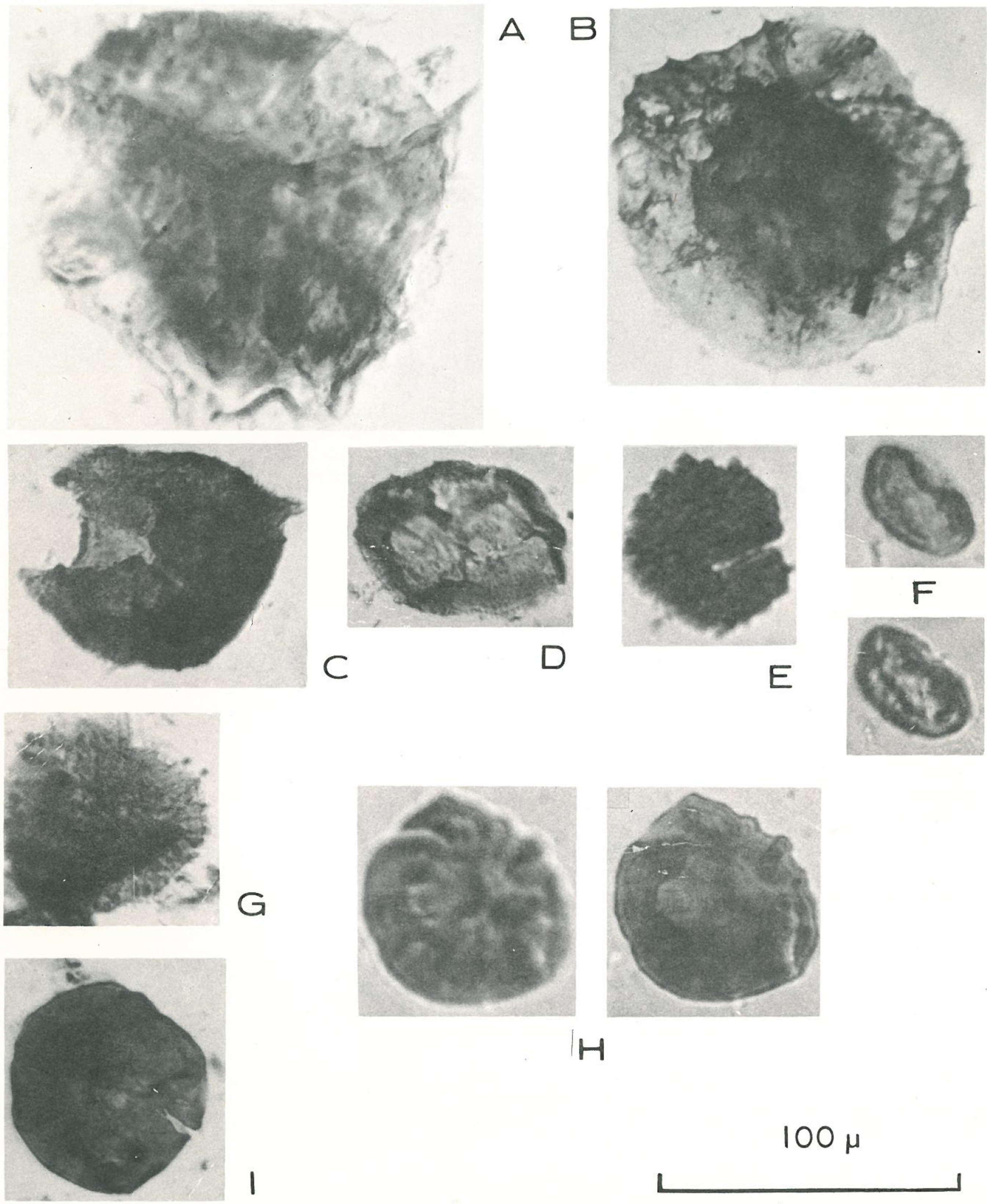


PLATE VIII

Representative plant sporomorphs

A.	Unidentified
B.	Unidentified
C.	Unidentified
D.	Unidentified
E.	Unidentified
F.	Unidentified

PLATE VIII