

https://dspace.org/

A review of the localities and flora of the lower Permian Karoo strata at Vereeniging, South Africa

LeRoux, S F Anderson, Heidi M

1977
Bernard Price Institute for Palaeontological Research
http://hdl.handle.net/10539/16223
None

Downloaded from a DSpace repository. https://dspace.org/

Palaeont. afr., **20**, 27–42 (1977)

A REVIEW OF THE LOCALITIES AND FLORA OF THE LOWER PERMIAN KAROO STRATA AT VEREENIGING, SOUTH AFRICA

by

S. F. le Roux and Heidi M. Anderson

ABSTRACT

The Vereeniging fossil floras are particularly well known and often referred to, as it is among them that attached glossopteridophyte fructifications were first recorded. No recent review of the localities, flora and age of the deposits is available. The history of collecting and description of fossil plants from Vereeniging dates from 1879. Ten localities have been recorded to date, the most important of which are the three Leeukuil quarries from which a diverse flora has been collected and described over the past thirty years. Two of the localities are considered to fall within the Lower Ecca and the remaining eight within a restricted section of the Middle Ecca coal measures. The older flora is poorly known and is represented only by the genera *Gangamopteris* and *Noeggerathiopsis*. The younger flora is fairly comprehensively known and includes some 23 genera and 33 species of plants.

CONTENTS

	Page
STRATIGRAPHY, CORRELATION AND AGE	27
HISTORICAL REVIEW 1879–1976	29
LOCALITY DESCRIPTIONS	30
1. The Falls	30
2. Klip River Quarry	32
3. Old Sandstone Quarry, Leeukuil	32
4. Shale Quarry, Leeukuil	32
5. River Quarry, Leeukuil	35
A. Fossil Forest	35
B. Dolomite Quarry	35
C. Suikerbosrand River	37
D. Central Colliery Dump	37
E. Corner Smuts Avenue and Voortrekker Street	37
THE MACROFLORA	37
ACKNOWLEDGEMENTS	37
REFERENCES	42

STRATIGRAPHY, CORRELATION AND AGE

Where Vereeniging is mentioned below, the area being considered is that covered by the map in Figure 1.

Basement

The Karoo sediments at Vereeniging lie on a very irregular basement topography of the Precambrian Transvaal System (Supergroup). The northern half of the map area (with localities 2, B, C and E) is underlain by dolomites, the south-western portion (with localities 1, 3, 4, 5, A and D) essentially by quartzites and shales. In view of this irregular floor, forming part of the northern shore region of the Karoo basin (Figure 1), the strata are lenticular in nature, are variable in thickness and are not readily correlated.

Dwyka Tillite

No unequivocal Dwyka Tillite is known to occur at Vereeniging.

Lower Ecca

The monotonous succession of shales and siltstones typical of the Lower Ecca stable shelf deposits farther to the south are not developed along the northern shore region of the basin (Ryan, 1968). The time equivalent, filling the low-lying portions of the pre-Karoo surface at Vereeniging, is a coarse-grained conglomeratic facies. This resembles concrete, with a fine-grained siliceous matrix and a wide variety of included pebbles. It weathers dirty white and is of very variable thickness, reaching a maximum of 4 m. This deposit has in the past often been regarded as Dwyka Tillite, but it is now generally agreed that it represents the Lower Ecca (Nel and Jansen, 1957; Cillie and Savage, 1961; Stratten, 1968; J. M. Anderson, 1975).

Localities B (Dolomite Quarry) and C (Suikerbosrand River) occur in this horizon. The senior author has searched extensively through the exposures of this conglomerate at Vereeniging but has been unable to find any further plant material within it. One

locality was found, however, which yielded thin laminated shales with arthropod trackways (A. M. Anderson, 1974).

Middle Ecca

The remaining eight localities all fall within the Middle Ecca coal measures, which are, at Vereeniging, very incomplete relative to their development elsewhere in the northern Karoo region. Whereas, in the Cornelia, Clydesdale and Sigma Collieries to the south and south-west of Vereeniging (extending from just south of the Vaal River for some 25 km) three workable coal seams occur; only one is developed in the map area. This seam can be shown through mine workings and borehole cores to be the topmost of the three (Cillie and Savage, 1961).

The plant-bearing horizons at all eight remaining localities fall within 20 m or so of Middle Ecca strata overlying this coal seam. It is interesting to note that abundant leaf impressions occur in the carbonaceous shales immediately overlying the top seam in the Cornelia Colliery (Smith, pers. comm. 1972). It might be assumed that all these fossiliferous beds represent a relatively narrow span of time.

Although much palynological work has been done throughout the Permian succession of the northern Karoo region (J. M. Anderson, 1977) no results have been obtained from Vereeniging as such. According to J. M. Anderson (1976, pers. comm.) the samples analysed from the fossiliferous horizons at the Leeukuil quarries all proved to be barren. The nearest locality yielding spores and pollens was the Sigma Colliery where typical Middle Ecca assemblages were obtained.

Overburden

No Karoo strata younger than Middle Ecca occur at Vereeniging, the coal measures being directly overlain over much of the area by about 0,5 m of Recent river gravels, followed by about 0,5 m of top-soil.

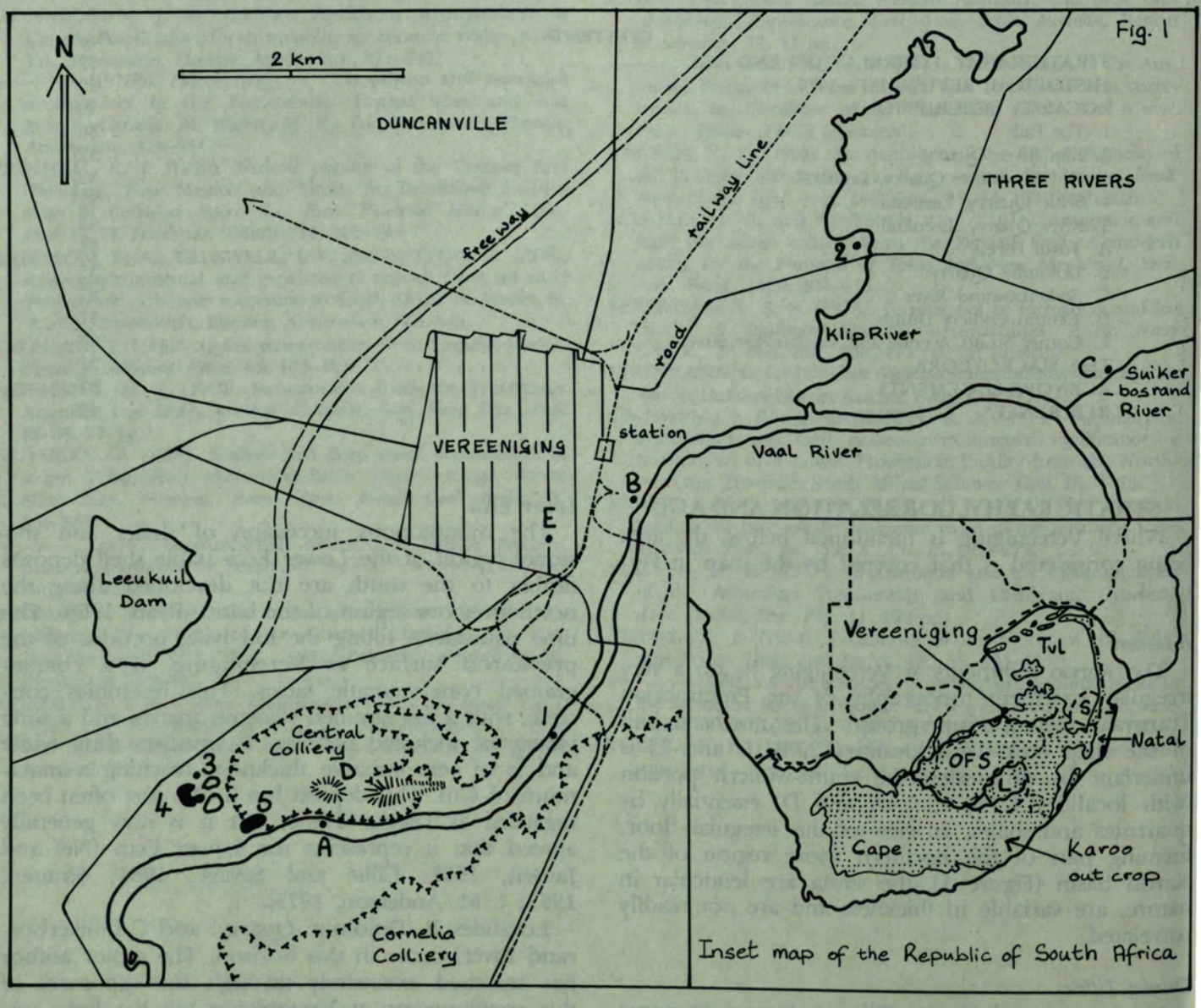


Figure 1. Map showing (a) the position of Vereeniging and (b) the localities, 1–5, and A–E, in the Vereeniging district described herein.

Age

According to the correlation charts (J. M. Anderson, 1973; 1975) using all available palaeontological and other data, the following ages for the Karoo strata occurring at Vereeniging may be postulated:

Middle Ecca — Lower Artinskian } Lower Permian
Lower Ecca — Middle Sakmarian }

HISTORICAL REVIEW 1879–1976

In the following review where original and revised generic designations are given in brackets, the author is recorded in Table 1.

Stow, 1879.

The first person on record to discover and collect plant fossils from the Vereeniging area (locality 1 as numbered in this paper) was G. W. Stow, who described the coal field of the central Vaal valley in his geological report of 1879. The subsequent exploitation of this coal field led to the establishment of Vereeniging which was proclaimed a town in 1892. It was T. N. Leslie (1922) who first brought to notice the good collection of fossil plants Stow had made and donated to Bloemfontein Museum. This material had hitherto gone unnoticed.

Leslie, 1892 to early 1900s.

T. N. Leslie, one of the pioneers of the town of Vereeniging, combined his trade as stone mason with his hobby, geology. During the early 1890s and 1900s he collected numerous fossil plants from two exposures he worked in his capacity as a stone mason. One of these was the original site in the bed of the Vaal River (locality 1) from which Stow had collected and the second was the Klip River Quarry (locality 2).

Draper, 1897.

D. Draper described a locality in the following terms "two miles east of Vereeniging, and close to the junction of Klip and Vaal Rivers, a sandstone-quarry was opened". From this locality, Draper sent a collection of fossil plants to A. C. Seward, who described them (Seward, 1897). The position of this locality is uncertain but in the authors' opinion it is probably equivalent to the Klip River Quarry (locality 2). However, it is strange that Seward and Leslie (1908) do not clarify this and that they refer to it in terms that suggest it may be a separate locality.

Seward, 1897, 1898, 1903.

A. C. Seward published the first systematic descriptions of fossil plants from Vereeniging in 1897. These comprised various species of *Glossopteris, Gangamopteris, Noeggerathiopsis, Sigillaria (Lycopodiopsis)* and *Conites (?Scutum)* and were derived from the uncertain quarry (probably locality 2), mentioned above. Based on comparisons with floras from other countries he suggested that the coal-bearing strata around Vereeniging were of Permo-Carboniferous age. A further short account of various species followed in 1898, based on material sent by a geologist, Hatch, from the same locality. Species belonging to the genera *Glossopteris, Gangamopteris, Neuropteridium (Gondwanidium), Bothrodendron (Cyclodendron), Psygmophyllum* and *Noeggerathiopsis* were described by Seward in 1903 from material collected by Leslie.

Leslie, 1904.

T. N. Leslie clarified that the fossils described by Seward in 1903 were obtained from two of his sandstone quarries. These two localities (localities 1 and 2) were briefly described and a short account of the flora was included.

Mellor and Leslie, 1906 described a fossil forest in the bed of the Vaal River (locality A) which became exposed due to extreme low water and has never been seen again.

Seward and Leslie, 1908 discussed the geology and age of the fossiliferous strata at Vereeniging and drew up a generalized geological section for the area. Various species (some new) belonging to the genera *Glossopteris, Gangamopteris, Callipteridium (?Pecopteris), Lepidodendron (Lycopodiopsis), Cordaites (Noeggerathiopsis)* and *Conites (Scutum)* were described.

Thomas, 1921, described a fructification (from locality 2) and placed it in the genus *Ottokaria* which was subsequently regarded as a *Scutum* by Plumstead (1952).

Leslie, 1922, referred to a further plant locality, namely his Dolomite quarry (locality B) near Vereeniging station, where thin bands of laminated shale yielded numerous *Gangamopteris* impressions.

Du Toit, 1926, 1932.

In his text book on South African geology (1926) Du Toit gave a general review of the "Ecca Series" fossil flora which included the Vereeniging plants. In 1932 he described *Stigmaria ficoides* from the Central Colliery dump (Locality D).

Le Roux, 1949.

The description of *Pecopteris* (from locality 3, Le Roux, 1949) heralded the publishing of numerous further papers after an interim of seventeen years. This renewed activity was largely due to extensive collecting by the senior author. From 1941 onwards, collections were made at Leslie's Klip River quarry (locality 2) and at an abandoned sandstone quarry (locality 3) on the farm Leeukuil where a series of fossiliferous shale bands was discovered. During 1946 large scale excavations were commenced by the Vereeniging Brick and Tile Company. This developed into extensive quarrying of the refractory shales from four closely situated quarries. The senior author then transferred his activities in late 1946 to two of these (localities 4 and 5) which were

fossiliferous. Over a period of three years a comprehensive collection was accumulated, including numerous specimens of attached *Glossopteris* fructifications. These were handed over to Dr. E. P. Plumstead for description.

The majority of the following papers describing new genera and species deal solely with material from localities 3, 4 and 5.

Plumstead, 1952, 1956a and b, 1958a, 1962.

In this series of papers the now famous *Glossopteris* and *Gangamopteris* fructifications, including 6 new genera and 19 new species, were described.

Plumstead, 1957, 1961, 1963, 1966a and b, 1967, 1969, 1970, 1973.

These papers include general reviews of a variety of aspects of the "Permo-Carboniferous" macrofloras of Southern Africa. The Vereeniging Coal Measure assemblages play a significant role throughout. Only in the 1961 paper were new taxa described — *Jongmansis transvaalensis* (regarded as a pteridospermous male fructification), *Lerouxia transvaalensis* (taken to be a bennettitalean flower) and *Taeniopteris gemmina.*

Le Roux, 1960, described a conchostracan *(Cyzicus)* from the River Quarry (locality 5). This remains the only invertebrate to be described from Vereeniging.

Kräusel, 1960a and b, 1961.

In the 1960a and 1961 papers, R. Kräusel described a number of lycopods from Vereeniging belonging to the genera *Lycopodiopsis, Cyclodendron,* and *Lycopodophlois,* whilst in the 1960b paper brief general reference to the fossils at Vereeniging was included.

Le Roux, 1963a and b, 1965, 1966, 1970, 1975, 1976.

In this series of papers S. F. le Roux described the bulk of the Leeukuil quarry material belonging to the Cycadophyta, Ginkgophyta and Coniferophyta. Two new genera and three new species were introduced.

LOCALITY DESCRIPTIONS

Intermittent collecting from the Shale and River Quarries (localities 4 and 5) was undertaken by Dr. Plumstead, the senior author and various students throughout the fifties and sixties. By 1954 large-scale quarrying operations by Vereeniging Refractories ceased and the quarries have in part been inundated by water (locality 5) or overgrown by vegetation. Recently (November, 1975) quarrying operations were recommenced at the north-eastern border of the River Quarry (locality 5). Should the quarrying be continued and the rich fossiliferous horizons be exposed, a third phase of palaeobotanical investigations at Vereeniging may be initiated.

The palaeobotanical localities of Vereeniging are here divided into two groups, based on their relative importance: localities 1–5 which have yielded the majority of fossil plants to date and localities A–E which are of only minor importance. Within each group in turn the localities are described in order of discovery and excavation. As far as can be ascertained this is a comprehensive list of localities.

(1) The Falls (Bed of Vaal River)

Location: 27°55′53″E/26°41′56″S. This locality is no longer exposed and Leslie's (1904) original description is thus quoted

> ". . . about 1½ miles *west* of Vereeniging. It is a sandstone bar across the Vaal River, and is known as the 'Falls'. The coal is exposed, and it was at this spot that Stow discovered the coal in 1879. (It was here that he died, and his remains lie within a stone's throw of the spot.)".

(N.B. The word "West" was applied in error by Leslie and should read "South".)

This locality is situated in the bed of the Vaal in an area which is now permanently under water. The reason for the change of water level was the building of the Barrage (damming up the river's flow) 32 kilometres downstream, in 1924. Before that date the river bed during the winter months was, to a large extent, exposed. Leslie's reference to Stow's grave in the above quotation does not throw any light on the problem either, since all attempts to locate Stow's grave have failed in spite of intensive research by several workers.

Description

Leslie (1904) described the exposure as follows: "the bar consists of about five feet of the lower beds of the sandstone. It has been faulted up rather sharply. The top beds have been eroded". The relationship of the sandstone to the coal horizon was not indicated by Leslie.

History

It was at this spot that Stow originally discovered coal in 1879 and the specimens he collected are in the Bloemfontein Museum. Leslie collected actively from this site (probably between 1892–1904) and in 1904 recorded that "quarrying operations gradually removed the bar exposed during low water".

Material

The following statement enables some of the material to be traced:

> "It is a dark grey sandstone with the leaf impressions beautifully black, but generally too coarse to get the delicate markings requisite for determination". (Leslie, 1904)

Such specimens are to be seen in the following museums: Bloemfontein Museum; S.A. Museum, Cape Town; Geological Museum, Johannesburg; Transvaal Museum, Pretoria; Bernard Price Institute for Palaeontological Research, Johannesburg; and the Vereeniging Museum. The most common genera represented in the above collections are

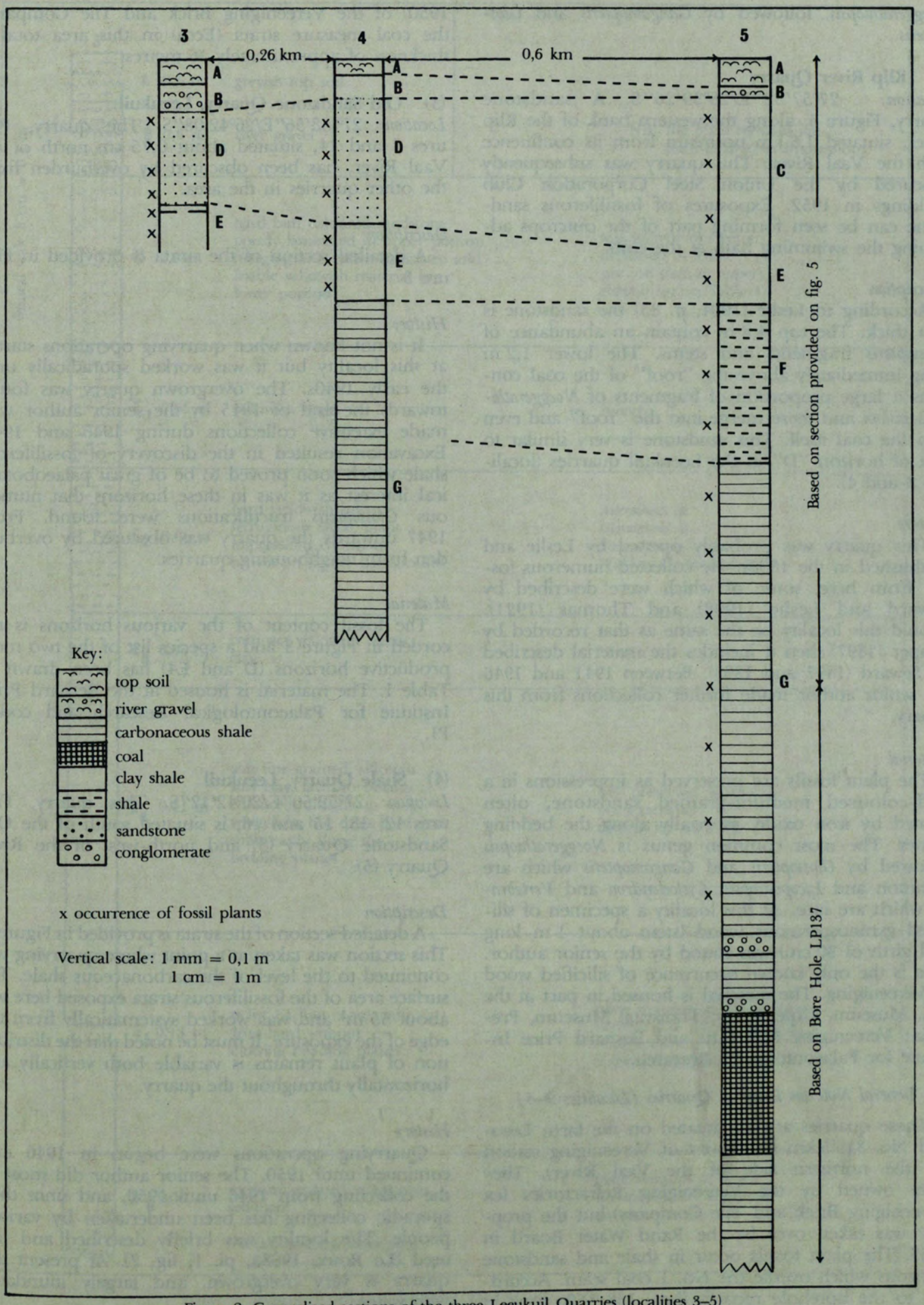


Figure 2. Generalised sections of the three Leeukuil Quarries (localities 3–5)

Noeggerathiopsis, followed by *Gangamopteris* and *Glossopteris.*

(2) Klip River Quarry

Location: 27°57′32″E/26°39′26″S. A sandstone quarry, Figure 6, along the western bank of the Klip River, situated 1,6 km upstream from its confluence with the Vaal River. This quarry was subsequently obscured by the Union Steel Corporation Club buildings in 1952. Exposures of fossiliferous sandstone can be seen forming part of the outcrops adjoining the swimming bath at the club.

Description

According to Leslie (1904, p. 85) the sandstone is 6 m thick. The top 4,8 m contain an abundance of *Glossopteris* fragments and stems. The lower 1,2 m lying immediately above the "roof" of the coal contains a large proportion of fragments of *Noeggerathiopsis hislopi* and these merge into the "roof" and even into the coal itself. This sandstone is very similar to that of horizon "D" in the Leeukuil quarries (localities 3 and 4).

History

This quarry was probably opened by Leslie and established in the 1890s. He collected numerous fossils from here, some of which were described by Seward and Leslie (1908) and Thomas (1921). Should this locality be the same as that recorded by Draper (1897) then it includes the material described by Seward (1897 and 1898). Between 1941 and 1946 the senior author made further collections from this quarry.

Material

The plant fossils are preserved as impressions in a buff-coloured medium-grained sandstone, often stained by iron oxide, especially along the bedding planes. The most common genus is *Noeggerathiopsis* followed by *Glossopteris* and *Gangamopteris* which are common and *Lycopodiopsis, Cyclodendron* and *Vertebraria* which are rare. At this locality a specimen of silicified gymnospermous wood (stem about 1 m long and girth of 30 cm) was found by the senior author. This is the only known occurrence of silicified wood at Vereeniging. The material is housed in part at the S.A. Museum, Cape Town; Transvaal Museum, Pretoria; Vereeniging Museum; and Bernard Price Institute for Palaeontological Research.

General Note on Leeukuil Quarries (Localities 3–5)

These quarries are all situated on the farm Leeukuil No. 81 (5 km south-west of Vereeniging station on the northern side of the Vaal River). They were owned by the Vereeniging Refractories (ex Vereeniging Brick and Tile Company) but the property was taken over by the Rand Water Board in 1963. The plant fossils occur in shale and sandstone horizons which overlie the No. 1 coal seam. According to the borehole records (nos. 158–160, sunk in 1950) of the Vereeniging Brick and Tile Company, the coal measure strata (Ecca) in this area total a thickness of approximately 16 metres.

(3) Old Sandstone Quarry, Leeukuil

Location: 27° 53′56″E/26°42′08″S. The quarry, Figures 7 and 14, situated about 0,75 km north of the Vaal River, has been obscured by overburden from the other quarries in the area.

Description

A detailed section of the strata is provided in Figure 3.

History

It is not known when quarrying operations started at this locality but it was worked sporadically until the early 1940s. The overgrown quarry was found towards the end of 1945 by the senior author who made extensive collections during 1946 and 1947. Excavation resulted in the discovery of fossiliferous shale which soon proved to be of great palaeobotanical interest as it was in these horizons that numerous *Glossopteris* fructifications were found. From 1947 onwards the quarry was obscured by overburden from neighbouring quarries.

Material

The fossil content of the various horizons is recorded in Figure 3 and a species list of the two most productive horizons (D and E4) has been drawn in Table 1. The material is housed at the Bernard Price Institute for Palaeontological Research and coded PI.

(4) Shale Quarry, Leeukuil

Location: 27°52′56″E/20°42′12″S. This quarry, Figures 12, 13, 15 and 16, is situated south of the Old Sandstone Quarry (3) and north-west of the River Quarry (5).

Description

A detailed section of the strata is provided in Figure 4. This section was taken at a point where quarrying was continued to the level of the carbonaceous shale. The surface area of the fossiliferous strata exposed here was about 55 m² and was worked systematically from the edge of the exposure. It must be noted that the distribution of plant remains is variable both vertically and horizontally throughout the quarry.

History

Quarrying operations were begun in 1946 and continued until 1950. The senior author did most of the collecting from 1946 until 1950, and since then sporadic collecting has been undertaken by various people. The locality was briefly described and figured (Le Roux, 1963a, pl. 1, fig. 2). At present the quarry is very overgrown, and largely inundated with water.

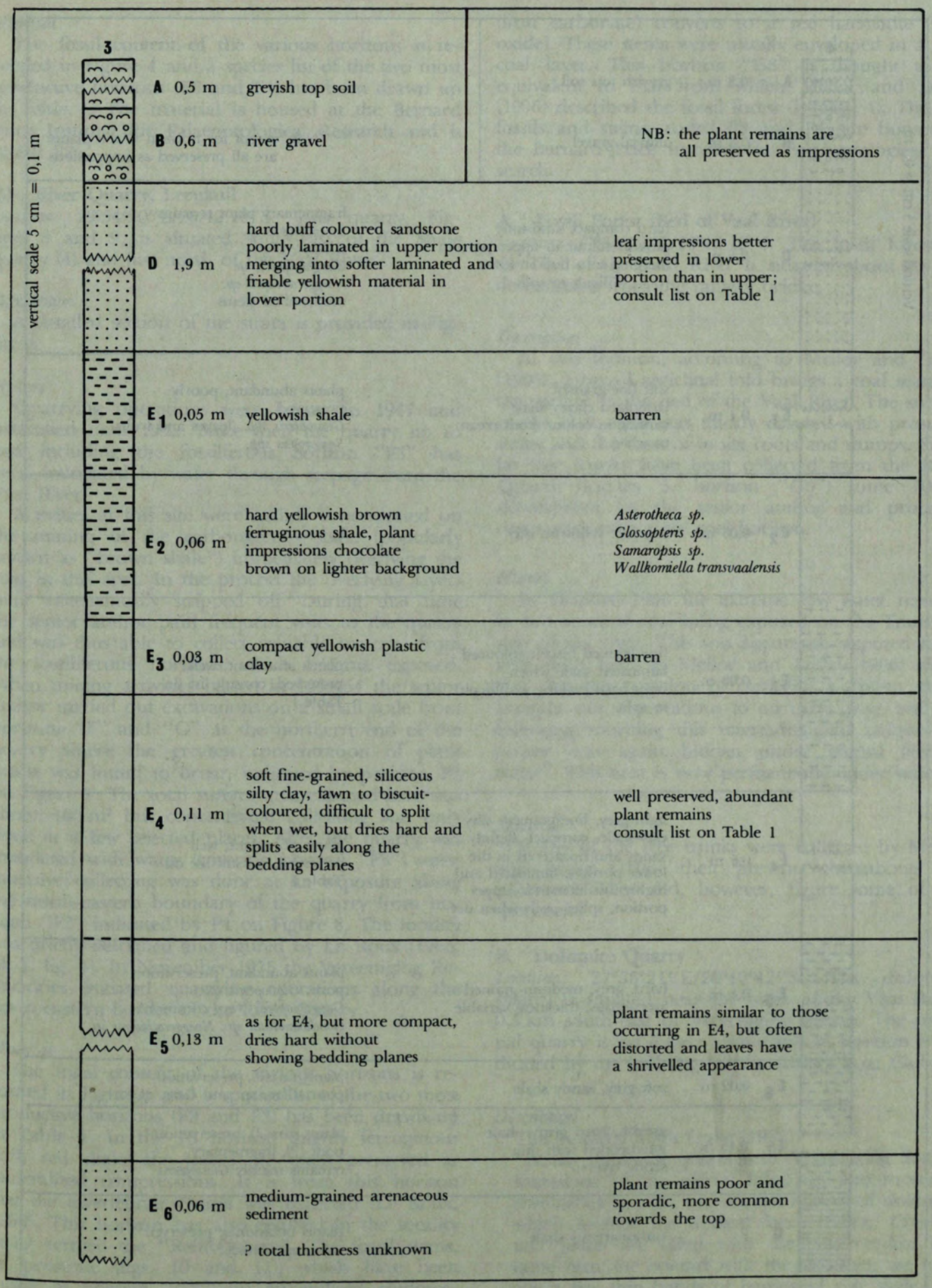


Figure 3. Section of strata at locality 3, Old Sandstone Quarry, Leeukuil.

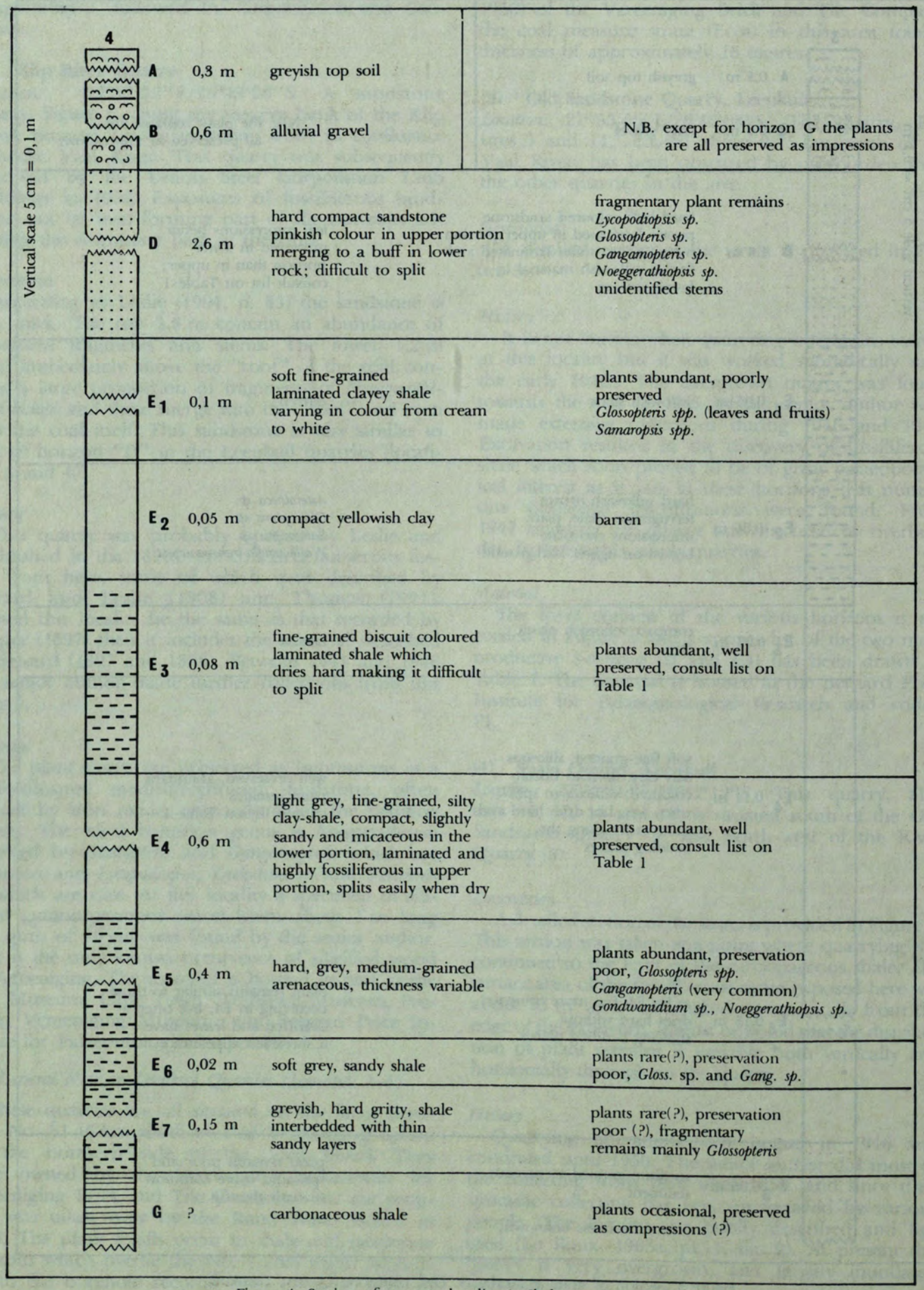


Figure 4. Section of strata at locality 4, Shale Quarry, Leeukuil.

Material

The fossil content of the various horizons is recorded in Figure 4 and a species list of the two most productive horizons (E3 and E4) has been drawn up in Table 1. The material is housed at the Bernard Price Institute for Palaeontological Research and is coded P2.

(5) River Quarry, Leeukuil

Location: 29°54′20″E/26°42′18″S. This quarry, Figures 8 and 9, is situated south-east of the Shale quarry (4) and just north of the Vaal River.

Description

A detailed section of the strata is provided in Figure 5.

History

Quarrying operations were begun in 1947 and continued until 1952. Since then the quarry up to and including the fossilferous horizon "F3" has been inundated by water through seepage from the Vaal River.

Activities at this site were mainly concentrated on the mining of the carbonaceous shale (popularly known as "brown shale") immediately overlying the coal in this area. In the process the overlying layers were systematically stripped off. During that time the senior author paid frequent visits to the quarry and was thus able to collect valuable material from the fossiliferous horizons which became exposed. When mining activities ceased in 1953/54 the senior author carried out excavations on a small scale from horizons "F" and "G" at the northern end of the quarry where the greatest concentration of plant fossils was found to occur, indicated by position P3 on Figure 9. The total surface area exposed here was about 100 m² but concentrated collecting was only done at a few selected places. After the quarry was inundated with water (covering horizon "F3") some intensive collecting was done at an exposure along the north-eastern boundary of the quarry from horizon "F2" indicated by P4 on Figure 8. The locality was briefly described and figured by Le Roux (1963, pl. 1, fig. 1). In November 1975 the Vereeniging Refractories initiated quarrying operations along the north-eastern border of the River Quarry.

Material

The fossil content of the various horizons is recorded in Figure 5 and a species list of the two most productive horizons (F2 and F3) has been drawn up in Table 1. In the F3 horizon (highly ferruginous dark red shale) the fossils are often preserved as mineralized compressions. It is from this horizon that the invertebrate *Cyzicus* was collected (Le Roux, 1960). This horizon has also resulted in the locality being termed the "Red Quarry". The fossil stems, all prostrate (figs. 10 and 11), which have been found in horizon "G3" are mineralized compressions. Upon exposure the grey coloured siderite (iron carbonate) converts to a red haematite (iron oxide). These stems were usually enveloped in a thin coal layer. This horizon "G3" is thought to be equivalent to that from which Mellor and Leslie (1906) described the fossil forest (locality A). The leaf fossils and stems, coded P3 and P4, are housed at the Bernard Price Institute for Palaeontological Research.

A. Fossil Forest (Bed of Vaal River)

Location: 27°54′42″E/26°42′19″S. The fossil forest in the bed of the Vaal River is situated about 2,8 km downstream from the railway bridge.

Description

At this location, according to Mellor and Leslie (1906), a broad anticlinal fold brings a coal seam to the surface in the bed of the Vaal River. The surface of the coal seam was thickly covered with prostrate stems and the casts of *in situ* roots and stumps. Similar tree trunks have been collected from the River Quarry (locality 5, horizon "G3") some 700 m downstream by the senior author and probably occur above the same coal horizon.

History

In October 1906 the extreme low water resulted in two acres of coal being exposed on the Transvaal side of the river. This was apparently exposed for a very short time as Mellor and Leslie (1906) wrote that "on the occasion of our visit a violent storm brought our observations to an early close, and the following morning this interesting and unique exposure was again hidden under several feet of water". This area is now permanently under water.

Material

If any of the tree trunks were collected by Mellor and Leslie (1906) their present whereabouts are unknown. They did, however, figure some of the specimens.

B. Dolomite Quarry

Location: 27°56′21″E/26°40′42″S. The dolomite quarry is situated near the bank of the Vaal River, 0,5 km south-east of Vereeniging station. The original quarry is no longer visible and its position is indicated by the buildings of the Riviera Boat Club.

Description

This is taken from Leslie (1922):

"At my dolomite quarry near Vereeniging Station intrusions of the glacial filled up and moulded themselves around the uneven masses of dolomite which formed the ancient land surface. Crevices and joints are filled with the concrete-like till; quite near the contact with the dolomite are usually a few thin bands of laminated clay shale, the lamina being a ¼ inch thick or even less."

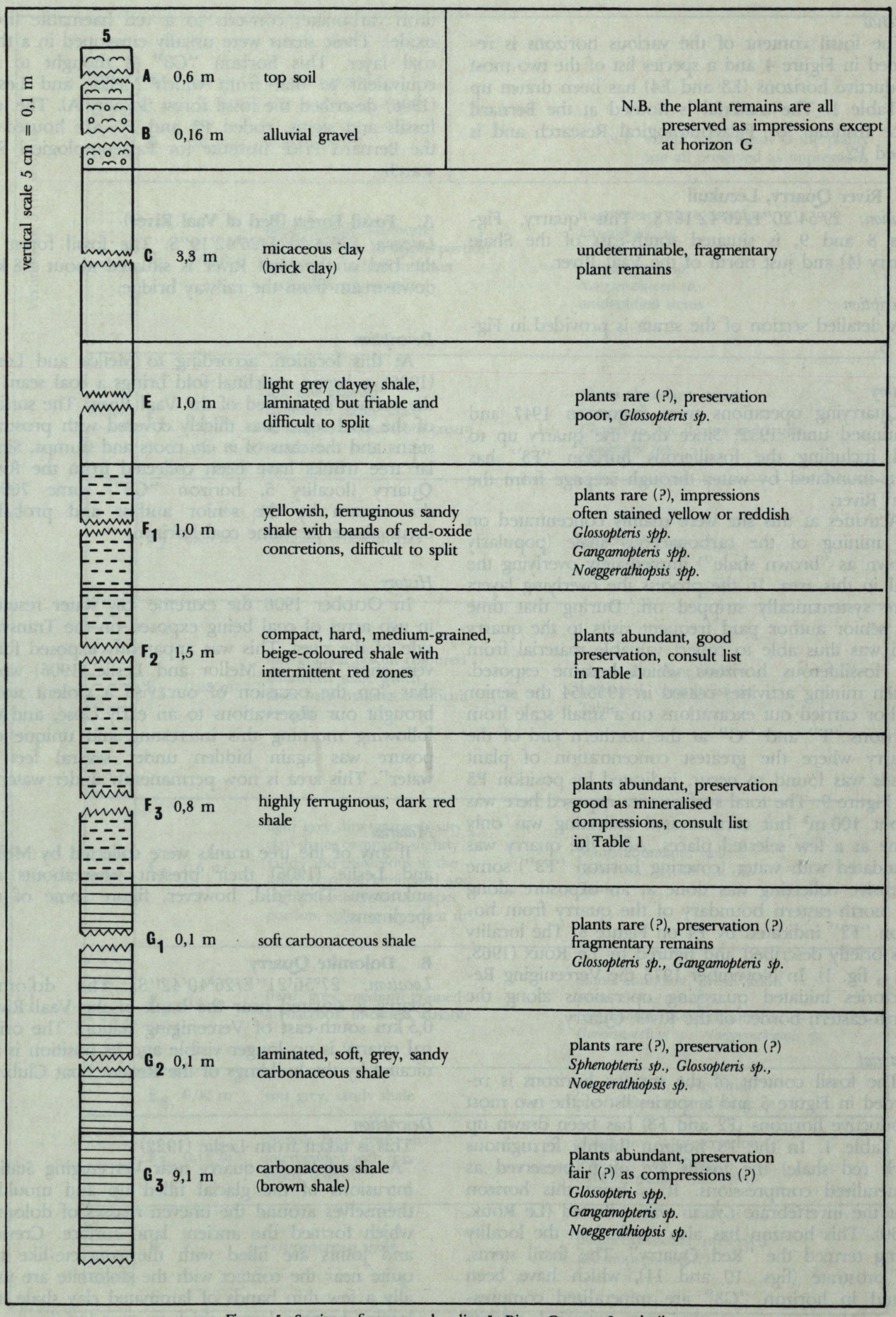


Figure 5. Section of strata at locality 5, River Quarry, Leeukuil.

History

Quarrying operations started some time prior to 1922 and continued until 1939. The fossils were first reported by Leslie (1922) and have been figured by Plumstead (1969, Pl. 7, figs. 2–4).

Material

The only genus to be recorded was *Gangamopteris* of which the few available specimens are housed at the Bernard Price Institute for Palaeontological Research and form part of the Leslie Collection.

C. Suikerbosrand River

Although no collections are available from this locality it is included here to complete the overall record of plant fossils at Vereeniging.

Location: 27°58′47″E/26°40′05″S. Exposures along the banks of the Suikerbosrand River, 500 m from its confluence with the Vaal River.

Description

The only information provided by Leslie (1922) is the observation that long strap-shaped leaves of *Cordaites (Noeggerathiopsis)* existed in stratified beds. These he regarded as occurring in the "Dwyka". The same "concrete-like till" of locality B is well exposed along the Suikerbosrand River and overlies the dolomite more or less directly. It can be safely assumed that the leaves Leslie referred to were preserved in this horizon, and probably in thin intercalated laminated shales as at locality B.

D. Central Colliery Dump

Although this dump cannot be considered a true locality it is nevertheless included.

Location

The dump lies 4 km south-west of the Vereeniging station. The subsurface extent of the colliery workings is indicated on Figure 1.

History and material

Du Toit (1932) described a single specimen of *Stigmaria ficoides* (supposedly a lycopod root fragment). He writes of the specimen which was loaned to him by Dr. T. N. Leslie:

> "It was picked up not far from a waste dump at the Central Coal Mine at Vereeniging by R. H. Smith of that town and is presumed to have come from the workings of that colliery, though unfortunately such presumption cannot be established."

The Central Coal Mine was opened in 1890 and closed in 1910. The present whereabouts of the specimen are not known.

E. Corner Smuts Avenue and Voortrekker Street

Location: 27°55′51″E/26°40′54″S. On the south-west corner of the intersection of Smuts Avenue and Voortrekker Street, in the town of Vereeniging.

History and Description

In 1947 some workmen excavating a stormwater drain encountered a fossiliferous sandstone about 4 m below surface. The top 0,5 m or so of this horizon was removed. The senior author, on continuous alert for new sites, came across these workings at the time. The dark grey sandstone with black leaf impressions is very similar to that from locality 1, which suggests possible equivalence. Sandstones of this description have not, beyond these two localities, been encountered in the Vereeniging area.

Material

Only leaves of the genus *Glossopteris* occurred in the sandstone. A single specimen is housed in the Vereeniging Museum.

THE MACROFLORA

Lower Ecca

The Lower Ecca flora recorded to date is very meagre and is recorded from only two localities. It consists of the two genera, *Gangamopteris* and *Noeggerathiopsis*.

Middle Ecca

The Middle Ecca flora, on the other hand, is well represented, relatively diverse, and has been recorded from eight localities to date, and is best known from the three Leeukuil quarries. A comprehensive check list, with relative abundance ratings for all the species found to date, from the most prolifically bearing strata at these three quarries is presented on Table 1. In summary the flora may be recorded as follows (by Divisions according to Boureau 1970):

Lycophyta	—	3 genera, 4 species
Sphenophyta	—	3 genera, 3 species
Filicophyta	—	3 genera, 5 species
Glossopteridophyta	—	4 genera, 7 species
Pteridospermophyta	—	1 genus, 1 species
Cycadophyta	—	3 genera, 4 species
Ginkgophyta	—	4 genera, 6 species
Coniferophyta	—	2 genera, 3 species
	Total—	23 genera, 33 species

This is based solely on the leaves and non-gymnospermous stems which are listed in Table 1. This tally is presumed to reflect reasonably accurately the flora growing at Vereeniging after the cessation of coal swamp development. The gymnospermous fructifications and fossil wood (which remain unstudied) have not been counted as they are probably largely represented by the equivalent leaf species.

ACKNOWLEDGEMENTS

Grateful thanks are due to Vereeniging Refractories Limited (formerly known as Vereeniging Brick and Tile Company) and also to the management of the Rand Water Board for permission to collect plant fossils on their properties.

This paper was in an advanced state of preparation when the senior author regrettably died (2 August 1976). The greater part of the paper is a result of his work, while the junior author helped mainly in compilation of the text and figures.

TABLE 1. THE VEREENIGING MACROFLORA FROM THE LEEUKUIL QUARRIES (localities 3–5)

Relative abundance:
1 extremely rare
2 rare
3 occasional
4 common-to-abundant

Abbreviations for references:
Kr. Kräusel
LeR. Le Roux
Pl. Plumstead
* undescribed material

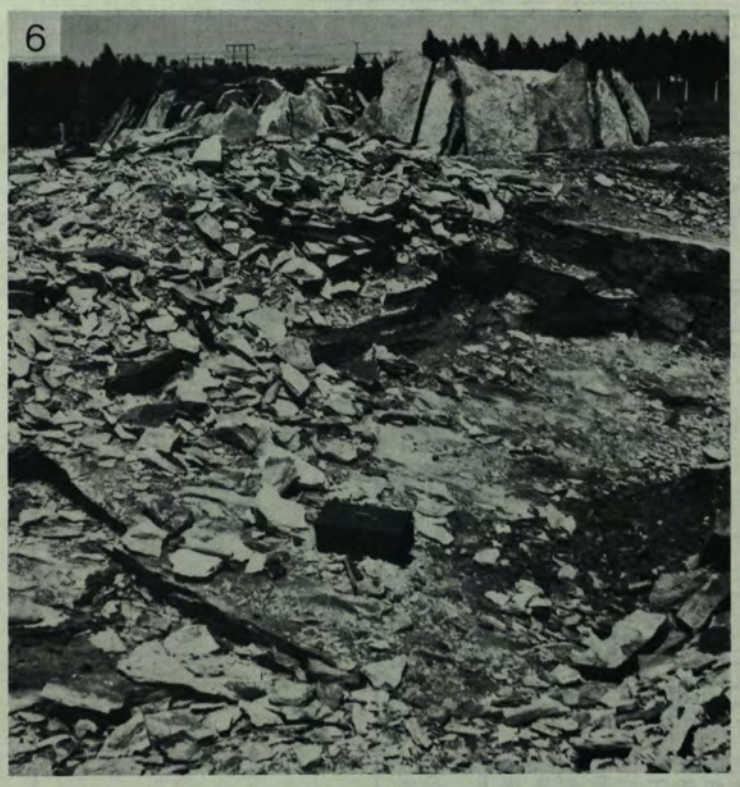
Notes:
This check list consists of all the species found to date, from the most prolifically bearing strata at these localities.

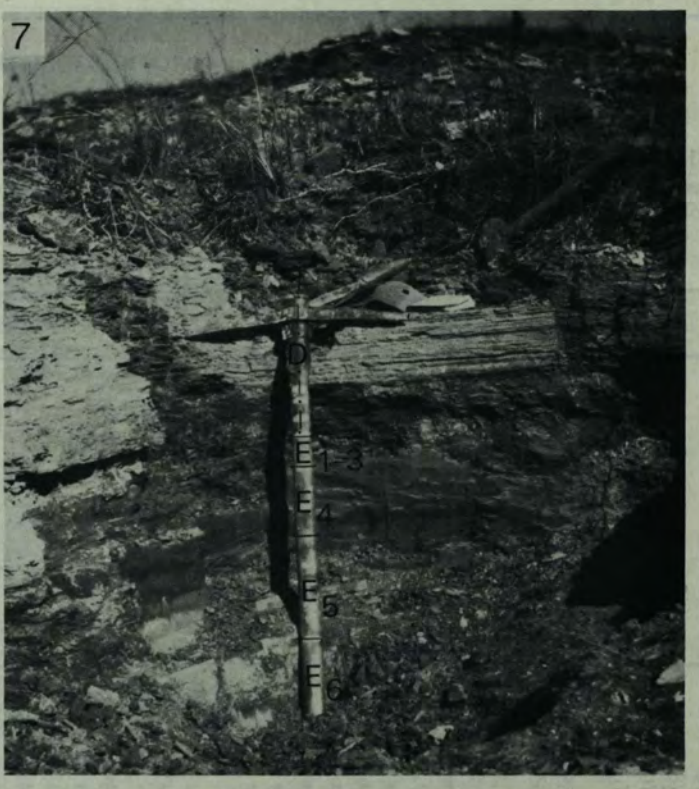
Genus	Species	Reference		Major groups after Boureau 1970	non-Gymnosperms (leaves & stems)	Gymnosperms (mainly leaves)
Cyclodendron	leslii (Sew.) Kr.	Kr. 1961		LYCOPHYTA		
Lycopodiophloios	dolianitii Kr.	Kr. 1961				
L.	edwardsi Kr.	Kr. 1961				
Lycopodiopsis	derbyi Renault	Pl. 1966				
? Phyllotheca (only stems)		Pl. 1957, 61, 66		SPHENOPHYTA		
? Schizoneura (only stems)	sp.	Pl. 1961				
Sphenophyllum	cf. thonii Mahr	LeR. 1976				
Pecopteris (Asterotheca)	singeri Arch.	LeR. 1976		FILICOPHYTA		
P. (A)	cf plumsteadiae H–M	LeR. 1976				
P.	sp.	LeR. 1949				
Cladophlebis	cf. nebbensis Brong.	LeR. 1976				
Sphenopteris	spp.	Pl. 1961				
Glossopteris	stricta Bunb.	Pl. 1958a 1	A	GLOSSOPTERIDOPHYTA		
G.	indica Schimper	Pl. 1952 3	B			
G.	intermittens Feist.	Pl. 1958a 4				
G.	longicaulis Feist	Pl. 1958a 5	C			
G.	damudica Feist.	Pl. 1958a 7	D			
G.	conspicua Feist	Pl. 1952 8				
G.	browniana Brong.	Pl. 1952 9				
G.	b.var cornelium Pl.	Pl. 1958a 10				
G.	tortuosa Zeiller	Pl. 1952 11				
G.	t. var. vaalense Pl.	Pl. 1958a 12				
G.	decipiens Feist.	Pl. 1958a 14				
G.	retifera Feist.	Pl. 1952 16	E			
Palaeovittaria	kurzi Feist.	Pl. 1958a 17				
Gangamopteris	buriadica Feist.	Pl. 1956b 18	F			
G.	obovata (Carr.) White	Pl. 1956b 19				
G.	cf. clarkeana Feist.	Pl. 1962 20	G			
scale leaves	spp.	*				
Gondwanidium	validum (Feist) Gothan	Pl. 1961		Pteridospermophyta		
Taeniopteris	gemmina Pl.	Pl. 1961				
T.	sp.	Pl. 1961		?CYCADOPHYTA		
Thomasleslia	vereenigensis	LeR. 1975				

		D	E3	E4	F1	F2	F3
Old Sandstone Quarry (locality 3)	D	3			1		
	E4			4 3 2		2 1	
Shale Quarry (locality 4)	E3		4 3 2 1		2	2 1	
	E4		4 3 2 1		2 1 2 1	1 1 3 4 4 2 1 3 4 3 3 3 1 4 2 2 4 1	2 3 2 1
River Quarry (locality 5)	F2					1	
	F3	1			1		1 2 2

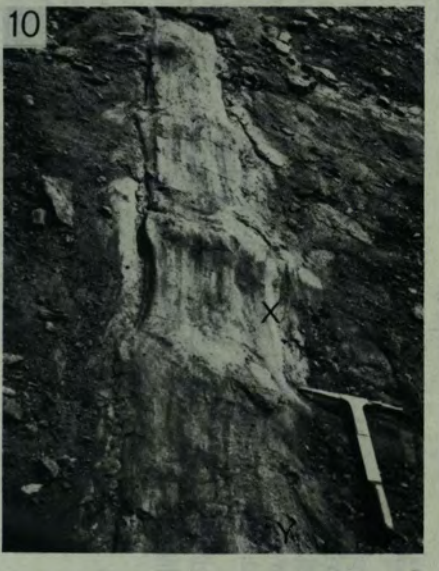
		D	E3	E4	F1	F2	F3
Old Sandstone Quarry (locality 3)	D				1	1	1
	E4				2 1	1 1 1 1 2 2 1 2 3 1 3 2 2 3·1	2 1 1 3 2
Shale Quarry (locality 4)	E3					1 3	2
	E4					1 1 3 4 4 2 1 3 4 3 3 3 1 4 2 2 4 1	2 3 2 1
River Quarry (locality 5)	F2					2 2	3 4 3 3 2
	F3					2 2 2 1 1 3 3 2	

| | | |


6


7
D
E1
E2
E3
E4
E5
E6


8
P4
C
E
F
G


10
X
Y


9
2
3
C
E
F
G
P3


11
X
Y











Figure 6. Locality 2, Klip River Quarry as it appeared in 1942 (direction of view not available).

Figure 7. Locality 3, Old Sandstone Quarry, Leeukuil, showing sandstone layer "D" overlying a succession of fine grained sediments E_1–E_6 (direction of view not available).

Figure 8. Locality 5, River Quarry, Leeukuil, showing succession of fossiliferous strata "G–G" (as viewed from the south-west) and position of collecting place P4.

Figure 9. Legend as for Figure 8, but viewed from the south-east and showing position of collecting place P3 and localities 3 and 4. A small portion of the Vaal River is visible at upper left. Position of tree trunk (fig. 10) marked by a ×.

Figure 10. A prostrate tree trunk in position of discovery at locality 5, total length exposed was more than 10 m.

Figure 11. Portion of tree trunk X–Y shown in Figure 8, with coaly matrix removed to show the lateral branching; now housed at Bernard Price Institute for Palaeontological Research, PB 312.

Figure 12. Locality 4, Shale Quarry, Leeukuil, showing fossiliferous horizons "D–G" and collecting point P2 at right (viewed from the south-east).

Figure 13. Legend as for Figure 12, showing detail of collecting point P2 and fossiliferous strata (viewed from the south-east).

Figure 14. Locality 3, Old Sandstone Quarry, Leeukuil, showing small scale excavation in progress in sandstone "D" (viewed from the west).

Figures 15. and 16: Locality 4, Shale Quarry, Leeukuil, showing method of excavating the fossiliferous strata "E_4 and E_5".

REFERENCES

(a) Comprehensive bibliography of Vereeniging plant fossils and localities

DRAPER, D. (1897). Notes on the occurrence of *Sigillaria, Glossopteris* and other plant remains in the Triassic Rocks of South Africa. *Q. Jl. geol. Soc. Lond.*, **53**, 310–314.

DU TOIT, A. L. (1926). *The Geology of South Africa.* 1st Edition. Oliver and Boyd, Edinburgh.

——— (1932). Some fossil plants from the Karroo system of South Africa. *Ann. S. Afr. Mus.*, **28(4)**, 369–393.

KRÄUSEL, R. (1960a). *Cyclodendron* Krsl, eine Lycopodiale sonderform der Permischen Gondwana Flora Afrikas. *Naturwissenschaften*, **47(23)**, 551–552.

——— (1960b). Die Permfloren der Süd-Halbkugel. *Berichten der Deutschen Botanischen Gesellschaft*, **73(7)**, 289–295.

——— (1961). *Lycopodiopsis derbi* Renault und andere Lycopodiales aus den Gondwana-Schichten. *Palaeontographica* Abt. B., **109(1–4)**, 62–92.

LE ROUX, S. F. (1949). A fossil plant of the genus *Pecopteris. South African Science* **2**, 132–133.

——— (1960). A fossil conchostracan from the Middle Ecca (Lower Permian) beds of Vereeniging. *S. Afr. J. Sci.*, **56(11)**, 282–284.

——— (1963a). On *Walkomiella transvaalensis*, a new conifer from the Middle Ecca (Lower Permian) beds of Vereeniging, Transvaal. *Trans. geol. Soc. S. Afr.*, **66**, 1–9.

——— (1963b). A new cycadeoid plant from the Permo-Carboniferous Coal Measures of the Transvaal. *Nature*, **199(4897)**, 1010–1011.

——— (1965). A new fossil plant with probable coniferous affinities, from Vereeniging. *S. Afr. J. Sci.*, **61(5)**, 199–201.

——— (1966). A new fossil plant *Plumsteadiella elegans*, from Vereeniging, Transvaal. *S. Afr. J. Sci.*, **62(2)**, 37–43.

——— (1970). Some fossil ginkgophytes and a possible Vojnovskyalean element from the *Glossopteris* flora of Vereeniging, Transvaal. *Palaeont. afr.*, **13**, 1–14.

——— (1975). A problematical element in the *Glossopteris* flora of Vereeniging. *Palaeont. afr.*, **18**, 31–34.

——— (1976). On some "Northern" elements in the Lower Gondwana Flora of Vereeniging, Transvaal. *Palaeont. afr.*, **19**, 59–65.

LESLIE, T. N. (1904). The fossil flora of Vereeniging. *Trans. geol. Soc. S. Afr.*, **6(4)**, 82–88.

——— (1922). Observations on some fossil plants from the Permo-Carboniferous of Vereeniging (Presidential address). *Proc. Geol. Soc. S. Afr.* **25**, xix-xxx.

——— (1939). *Casual memories of an octogenarian.* Unpublished manuscript, Vereeniging Library, 251 pp.

MELLOR, E. T. and LESLIE, T. N. (1906). On a fossil forest recently exposed in the bed of the Vaal River at Vereeniging. *Trans. geol. Soc. S. Afr.*, **9**, 125–128.

PLUMSTEAD, E. P. (1952). Description of two new genera and six new species of fructifications borne on *Glossopteris* leaves from South Africa. *Trans. geol. Soc. S. Afr.*, **55**, 281–328.

——— (1956a). Bisexual fructifications borne on *Glossopteris* leaves from South Africa. *Palaeontographica* Abt. B., **100**, 1–25.

——— (1956b). On *Ottokaria*, the fructification of *Gangamopteris. Trans. geol. Soc. S. Afr.*, **59**, 211–236.

——— (1957). *Coal in Southern Africa.* Witwatersrand University Press, Johannesburg, 1–24.

——— (1958a). Further fructifications of the Glossopteridae with a provisional classification based on them. *Trans. geol. Soc. S. Afr.*, **61**, 51–76.

——— (1958b). The habit of growth of the Glossopteridae. *Trans. geol. Soc. S. Afr.*, **61**, 81–94.

——— (1961). The Permo-Carboniferous Coal Measures of the Transvaal, South Africa — an example of the contrasting stratigraphy in the Southern and Northern Hemispheres. *4ème Congr. Géol. et Stratigr. Carbonif.*, **2**, 545–550.

——— (1962). *Vannus gondwanensis*, a new *Gangamopteris* fructification from the Transvaal, South Africa. *Palaeobotanist*, **11** (1 and 2). 106–114.

——— (1963). The influence of plants and environment on developing animal life of Karroo times. *S. Afr. J. Sci.*, **59(5)**, 147–152.

——— (1966a). Recent palaeobotanical advances and problems in Africa. In: *Symposium on Floristics and Stratigraphy of Gondwanaland*, Lucknow, Birbal Sahni Institute of Palaeobotany, 1–12.

——— (1966b). The story of Africa's coal. *Optima*, **16**, 186–202.

——— (1967). A review of contributions to the knowledge of Gondwana megaplant fossils and floras of Africa published since 1950. In: *Proceedings I.U.G.S. Symposium on Gondwana Stratigraphy, 1967, Mar del Plata* **1**, 139–148.

——— (1969). Three thousand million years of plant life in Africa. Du Toit memorial lecture number 11. *Trans. geol. Soc. S. Afr.* **72** (Annex.), 1–72

——— (1970). Guide Book No. 4. Post-symposium excursion to the Eastern Transvaal, Natal and the Drakensberg. 2nd I.U.G.S. Symposium on Gondwana Stratigraphy and Palaeontology, South Africa. Pretoria, C.S.I.R.

——— (1973). The late Palaeozoic *Glossopteris* flora. In: *Atlas of Palaeobiogeography* ed. by A. Hallam. Amsterdam, Elsevier, 187–205.

SEWARD, A. C. (1897). On the association of *Sigillaria* and *Glossopteris* in South Africa. *Q. Jl. geol. Soc. Lond.*, **53**, 315–340.

———(1898). Note on the plant remains from Vereeniging. *Q. Jl. geol. Soc. Lond.*, **54**, 92–93.

——— (1903). Fossil floras of Cape Colony. *Ann. S. Afr. Mus.*, **4 (i)**, 1–122.

——— and LESLIE, T. N. (1908). Permo-Carboniferous plants from Vereeniging (Transvaal). *Q. Jl. geol Soc. Lond.*, **64**, 109–126.

THOMAS, H. H. (1921). An *Ottokaria*-like plant from South Africa. *Q. Jl. geol. Soc. Lond.*, **77**, 285–288.

(b) Bibliography of additional references

ANDERSON, A. M. (1974). *Arthropod trackways and other trace fossils from the Early Permian Lower Karroo Beds of South Africa.* Unpublished Ph.D. thesis, University of the Witwatersrand, Johannesburg.

ANDERSON, J. M. (1973). The biostratigraphy of the Permian and Triassic. Part 2 (charts 23–35). — A preliminary review of the distribution of Permian and Triassic strata in time and space. *Palaeont. afr.*, **16**, 59–83.

——— (1977). The biostratigraphy of the Permian and Triassic. Part 3. A review of Gondwana Permian Palynology with particular reference to the northern Karoo Basin, South Africa. *Memoirs of the Botanical Survey of South Africa*, **41**, 1–67. 188 pls.

BOUREAU, E. (1970). Ed. *Traité de paléobotanique.* Vol. 4, Paris, Masson. Plates, 519 pp.

CILLIE, J. F. and SAVAGE, W. H. D. (1961). Die Steenkoolveld Vereeniging-Clydesdale. *Mem. geol. Surv. S. Afr.* **50**, 133 pp.

NEL, L. T. and JANSEN, H. (1957). The Geology of the country round Vereeniging. *Geol. Surv. S. Afr.* Explanation to sheet **62**, Vereeniging, 1–90.

RYAN, P. J. (1968). *Stratigraphic and palaeocurrent analysis of the Ecca series and lowermost Beaufort beds in the Karroo basin of South Africa.* Unpublished Ph.D. thesis, University of the Witwatersrand, Johannesburg.

STRATTEN, T. (1968). *The Duwka glaciation and its relationships to the Pre-Karroo surface.* Unpublished Ph.D. thesis, University of the Witwatersrand, Johannesburg.