MIOSPORE ZONES IN KARROO SEDIMENTS OF TANZANIA

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ABSTRACT

Miospore complexes from Karroo rocks of parts of the Songwe-Kiwira Coalfield and Ketewaka-Mchuchuma Coalfield, Tanzania, are described and correlated one with the other. The complexes are assigned to the lower part of the Permian System.

INTRODUCTION

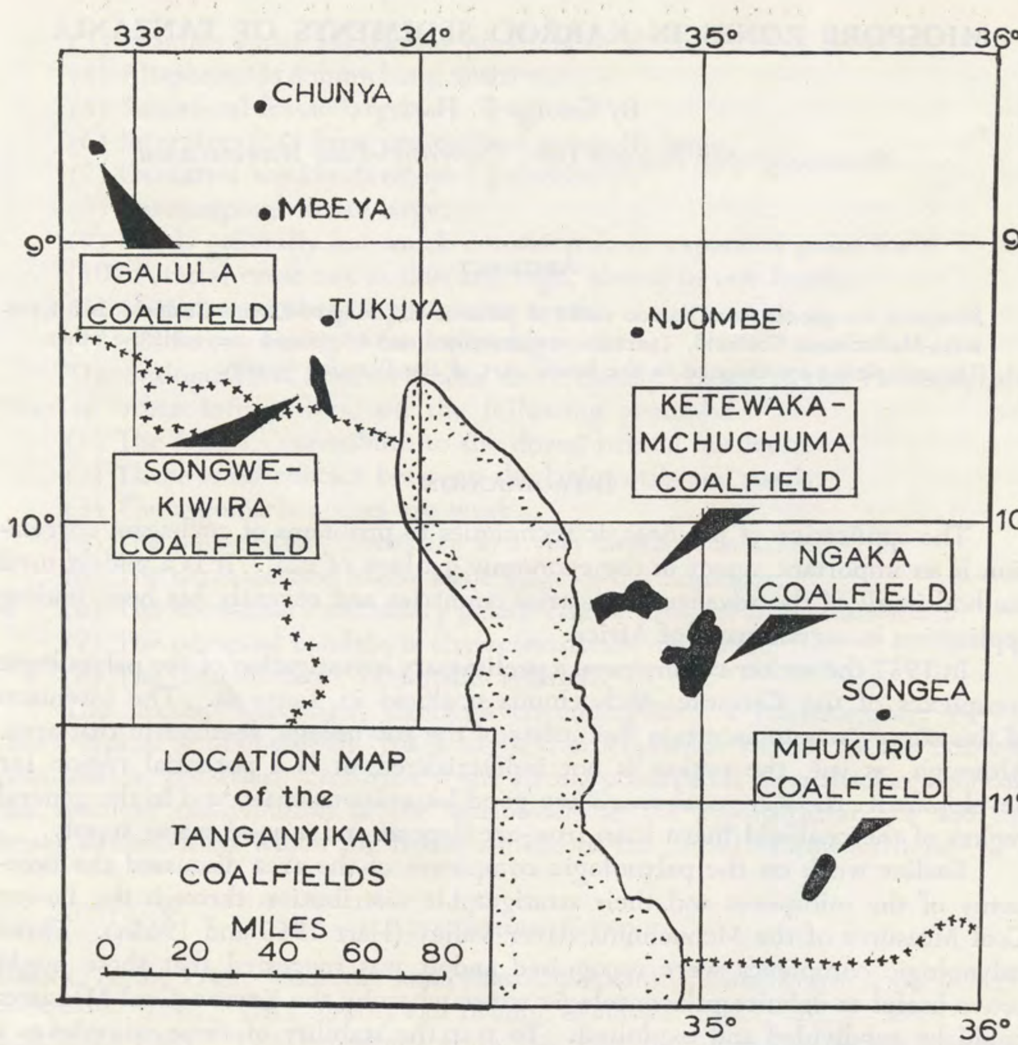
The application of palynologic techniques to problems of coal-seam correlation is an important aspect in the economic geology of coal. It is a widely used method in all of the advanced industrial countries and recently has been finding application in certain parts of Africa.

In 1957 the writer commenced a preliminary investigation of the palynologic complexes of the Ketewaka-Mchuchuma coalfield in Tanzania. The intention of this survey was to ascertain the utility of the palynologic method in that area. Although, as yet, the region is not industrialized, it is a potential region for development: the $K2e_1$ coal-seams are good bituminous coals, and in the general region of the coalfield there is an iron-ore deposit and a good water supply.

Earlier work on the palynologic complexes of the area discussed the taxonomy of the miospores and their stratigraphic distribution through the Lower Coal Measures of the Mchuchuma River Valley (Hart 1960 and 1965a). Three palynologic complexes were recognised and it was suggested that these might prove useful as definite palaeontologic zones whereby the Karroo Coal-Measures could be subdivided and exploited. To test the stability of these complexes a short succession of Karroo rocks from the Songwe-Kiwira Coalfield was analysed for miospores. The location of this test-area is about 160 km. from the Mchuchuma River Valley (see text-figure 51).

This report presents the results of this test and at the same time describes the palynologic complex from a farther site in the Mchuchuma Coalfield (i.e. the Nyakapenda River Valley). The results confirm the great practical value of miospore analysis for the correlation of Karroo strata.

The material analysed for miospores consisted of 14 samples of shale, coaly shale or coal from the Songwe-Kiwira Coalfield (Assemblage number 139-152) and 54 samples of coal from the Mchuchuma Coalfield (Assemblage numbers 8-20, 65-105). All of the former and 35 of the latter yielded an abundant and well preserved microflora of miospores and cuticle, and these were subjected to standard analysis (Hart 1962).



Text-Figure 51

The Mchuchuma Coal-Field Palynologic Complexes

The characteristics of the Mchuchuma Coal-field palynologic complexes as seen in the Mchuchuma River Valley were given by Hart (1965a). These results are summarized in text-figures 52 and 53 and the general features of each complex may be summarized as follows.

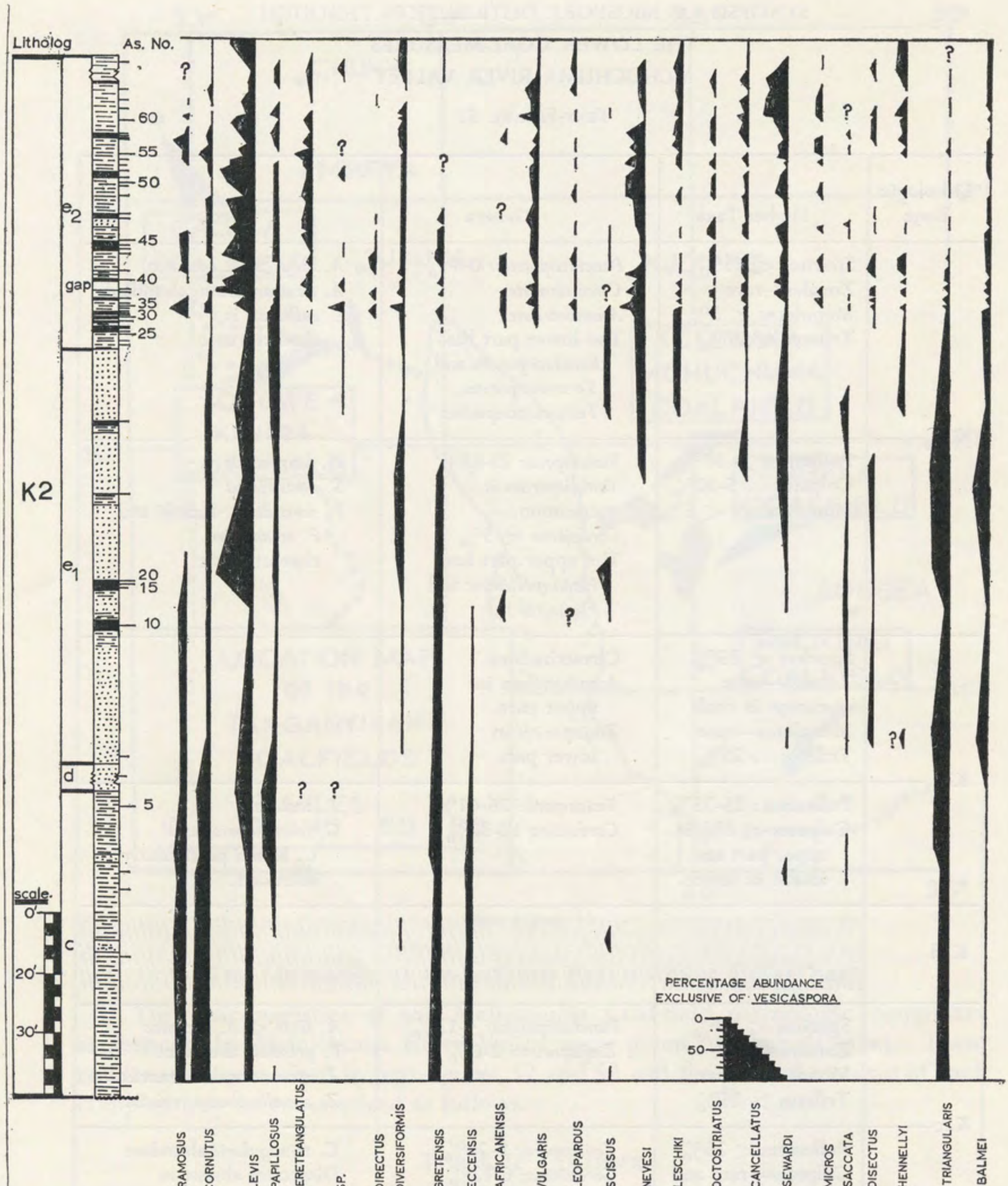
The K2c Complex

The strata are characterized by a large percentage of Sporites (>50%), and particularly in the abundance of Triletes (>25%). The Pollenites are not very common (usually <25% with a maximum of 35%) and are chiefly represented by *Vesicaspora* (8-28%) and *Cordaitina* (6-13%).

SYNOPSIS OF MIOSPORE DISTRIBUTION THROUGH THE LOWER COAL-MEASURES MCHUCHUMA RIVER VALLEY

TEXT-FIGURE 52

Lithologic Zone	Higher Taxa	Genera	Species
K2e$_2$	Sporites $< 25\%$ Zonales—rare Monoletes $< 5\%$ Triletes $\leqslant 20\%$	*Punctatisporites:* 0-4% *Cirratriradites* *Acanthotriletes* The lower part has *Baculatisporites* and *Verrucosisporites*. *Tuberculatosporites*	*A. levis* $>$ *A. cornatus* *A. tereteangulatus* abundant *L. colliensis* is characteristic.
	Pollenites $> 50\%$ Colpates . . 5-10% Monosaccites $< 5\%$	*Vesicaspora:* 29-68% *Vestigisporites is* common. *Cordaitina* $< 5\%$ The upper part has *Hamiapollenites* and *Florinites*	*H. karrooensis* *S. octostriatus* *P. sewardi*, *P. leschiki* and *F. eremus* are characteristic.
K2e$_1$	Sporites $\leqslant 25\%$ Zonales—rare except in coals Monoletes—rare Triletes . . 25%	Cirratriradites *Acanthotriletes* in upper part. *Zinjisporites* in lower part.	
	Pollenites: 25-75% Colpates $< 5\%$ in upper part and absent in lower.	*Vesicaspora:* 26-61% *Cordaitina* 10-30%	*V. saccata*, *C. triangularis*, and *C. balmei* particularly abundant.
K2d			
K2c	Sporites $< 50\%$ Zonales—rare Monoletes—rare Triletes $> 25\%$	*Punctatisporites:* 4-12% *Zinjisporites:* 2-6%	*A. levis* $<$ *A. cornutus* *P. gretensis* abundant *Z. eccensis* and *Z. restricta* *Z. zonalis* characteristic
	Pollenites $< 25\%$ Colpates—rare and only in upper portion.	*Vesicaspora:* 8-28% *Cordaitina:* 6-13%	*C. triangularis* abundant Disaccites absent in lower portions and very rare in upper portions.



Text-figure 53

A very characteristic feature of any K2c assemblage is the presence of *Zinjispora* (*Z. eccensis* 2-6%, *Z. zonalis* 1–2.5%, and *Z. restricta* rare).

Associated species include: *Cordaitina triangularis* (3-17%), *C. balmei* (r-3%), *Apiculatisporis levis* (2-17%), *A. cornutus* (10-18%), *Punctatisporites gretensis* (4-12%), *Neoraistrickia ramosa* (3-11%) and *Calamospora sp.*

A notable feature is that Disaccate genera, apart from the omnipresent *Vesicaspora*, are absent from the Lower K2c beds and very rare in the Upper K2c beds. The Colpates begin to form part of the upper assemblages in the K2c strata.

The $K2e_1$ Complex

The lowest part of the $K2e_1$ complex shows facets similar to the K2c complex; and the highest part facets similar to the $K2e_2$ complex.

The Monosaccites and Sporites, dominant in the lower beds, are replaced by a preponderance of Disaccites in the upper beds. A general assessment of the major taxa shows that the Sporites are $\leqslant$ 25% of the total assemblage (Triletes, about 25%), and the Pollenites are 25-75% (Colpates $<$ 5% and Monosaccites 10-30%).

Vesicaspora varies from 26-61%, *Striatoabietites* 2-3% and *Cordaitina* 2-29%.

The $K2e_2$ Complex

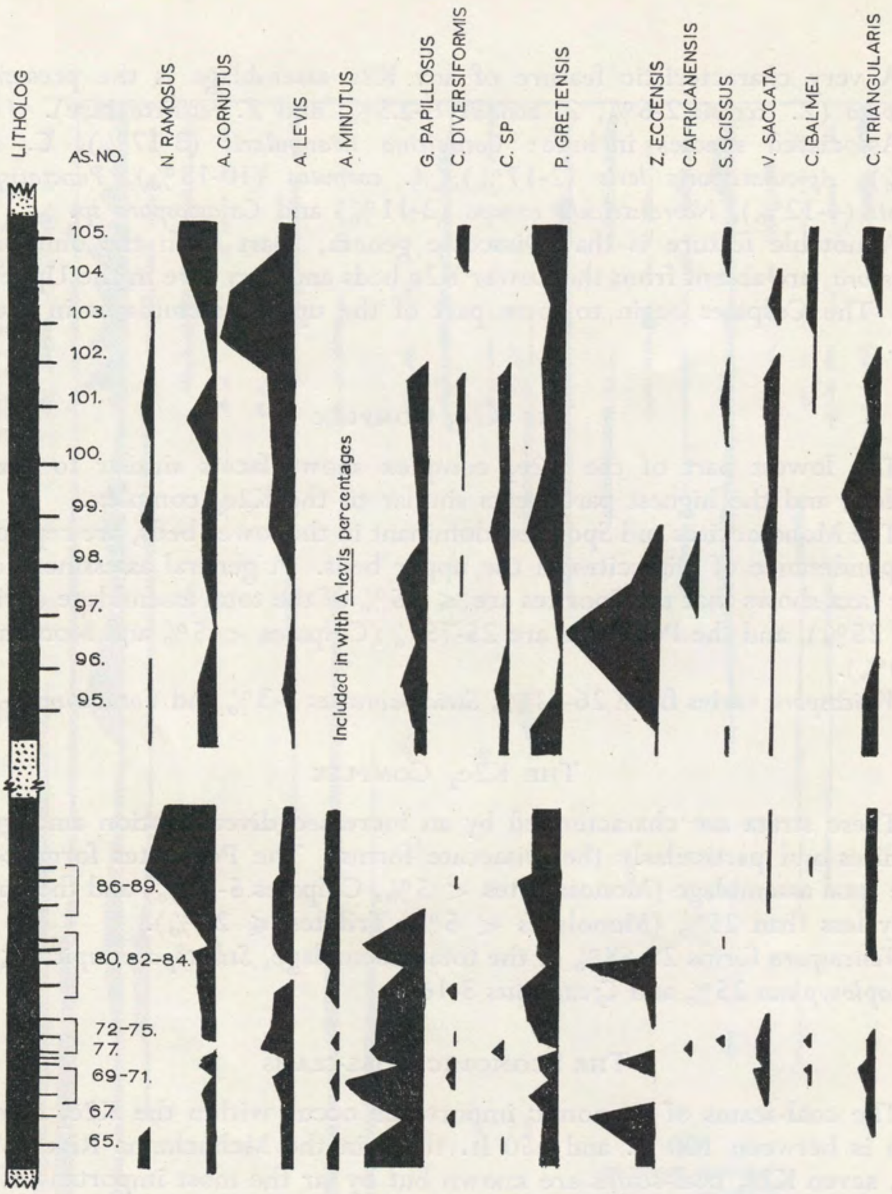
These strata are characterized by an increased diversification amongst the Pollenites and particularly the Disaccate forms. The Pollenites form $>$50% of the total assemblage (Monosaccites $<$ 5%, Colpates 5-10%) and the Sporites usually less than 25% (Monoletes $<$ 5%, Triletes $\leqslant$ 20%).

Vesicaspora forms 29-68% of the total assemblage, *Striatopodocarpites* $\leqslant$ 3%, *Protohaploxypinus* 25% and *Cycadopites* 3-16%.

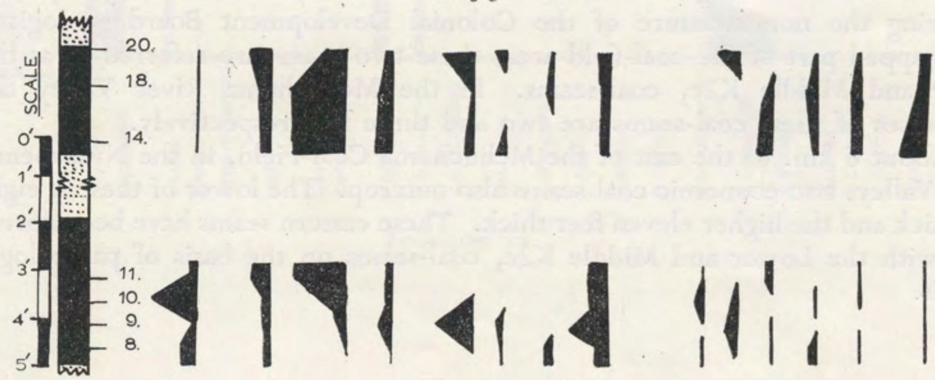
The Economic Coal-seams

The coal-seams of economic importance occur within the $K2e_1$ complex, which is between 100 ft. and 150 ft. thick in the Mchuchuma River Valley. In all, seven $K2e_1$ coal-seams are known but by far the most important of these are two seams occurring between 40-80 ft. from the base of the $K2e_1$ deposits. Following the nomenclature of the Colonial Development Board geologists, who mapped part of the coal-field area, these two seams are referred to as the Lower and Middle $K2e_1$ coal-seams. In the Mchuchuma River Valley the thicknesses of these coal-seams are two and three feet respectively.

About 6 km. to the east of the Mchuchuma Coal-Field, in the Nyakapenda River Valley, two economic coal-seams also outcrop. The lower of these is eight feet thick and the higher eleven feet thick. These eastern seams have been correlated with the Lower and Middle $K2e_1$ coal-seams on the basis of palynologic analysis.



Text-figure 55



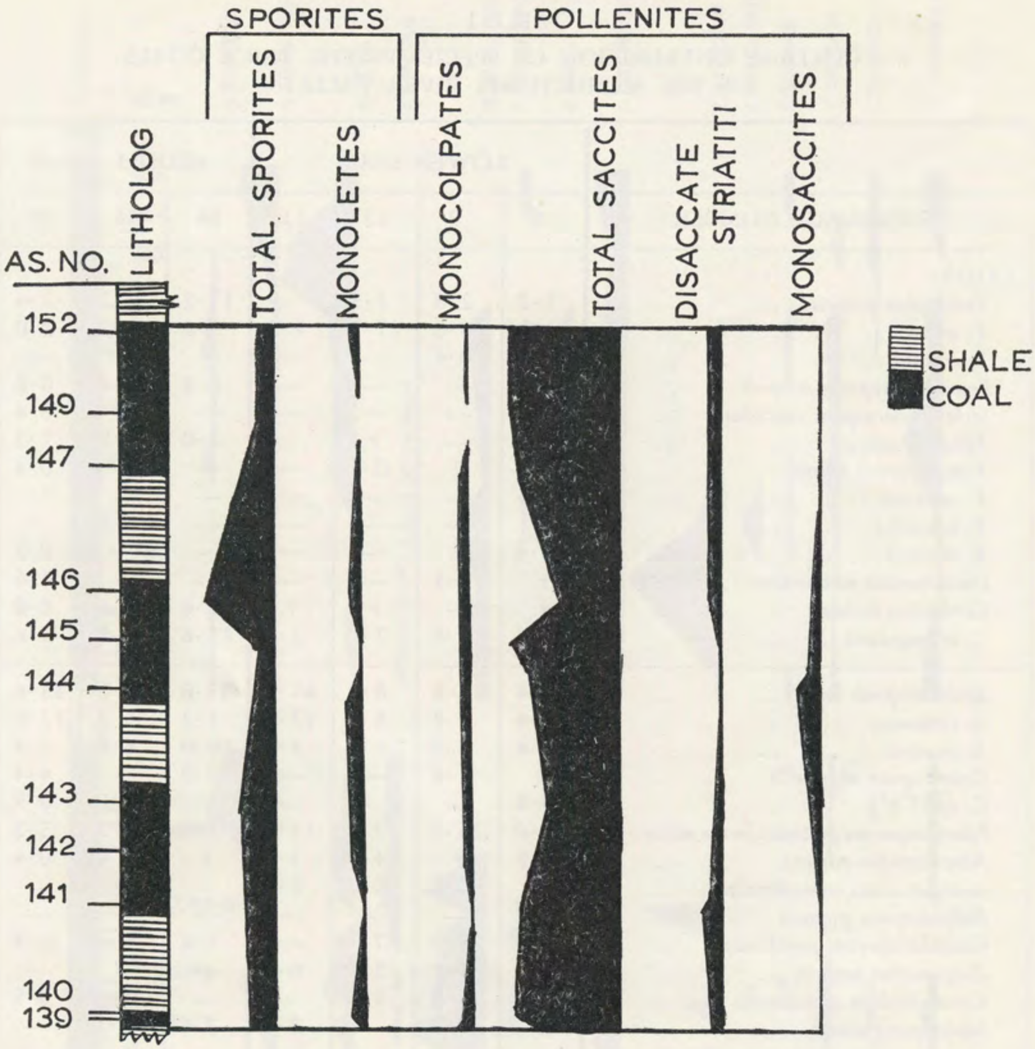
Text-figure 54

TABLE I

PERCENTAGE DISTRIBUTION OF SPECIES IN THE THICK COALS OF THE MCHUCHUMA RIVER VALLEY

	LOWER SEAM				MIDDLE SEAM		
ASSEMBLAGE NUMBER	8	9	10	11	14	18	20
TAXON:							
Vesicaspora potoniei	1·2	2·8	2·5	—	17·2	1·2	2·4
V. ovata	42·4	4·0	17·5	1·2	9·6	20·0	2·0
V. sulcata	0·4	0·4	—	—	—	—	—
Protohaploxypinus sewardi	—	—	—	—	0·4	2·4	0·8
Striatopodocarpites cancellatus	—	—	—	—	—	—	0·4
Vittatina saccata	2·0	—	r	—	2·0	4·8	1·2
Vestigisporites balmei	0·4	?	0·5	—	—	—	0·4
V. methoris	0·4	—	—	—	—	—	—
V. hennellyi	—	—	—	—	—	0·8	—
V. thomasi	0·4	?	—	—	—	—	0·8
Limitisporites monstruosus	r	0·4	—	—	—	—	1·6
Cordaitina balmei	r	—	r	r	1·6	2·4	0·8
C. triangularis	2·4	3·6	2·0	2·8	15·6	6·8	3·6
Apiculatisporis levis	0·4	6·8	8·5	45·6	33·6	38·0	13·6
A. cornuutus	2·4	2·8	5·5	17·6	1·2	5·2	12·0
A. minutus	0·4	7·2	1·5	4·0	10·0	6·8	2·4
Calamospora nigretella	r	2·8	—	—	0·8	—	4·4
C. sp. "A"	0·8	—	—	—	—	0·8	0·8
Punctatisporites gretensis forma minor . .	5·6	25·6	7·0	13·6	2·0	1·2	5·2
Neoraistrickia ramosa	2·8	r	24·0	3·2	r	0·4	0·4
Acanthotriletes tereteangulatus	—	0·4	5·0	2·4	—	—	—
Deltoidospora giganta	1·2	—	—	—	—	—	—
Granulatisporites papillosus	28·0	27·2	7·5	—	1·6	0·4	20·4
Zinjisporites eccensis	r	—	2·0	0·4	—	—	—
Cirratriradites africanensis	2·0	5·6	1·0	—	—	—	8·8
Schizosporis scissus	r	0·4	—	2·0	3·6	1·2	—

Text-figure 54 and Table 1 summarize the detailed palynologic characteristics of the two seams in the Mchuchuma River Valley, and figure 55 and Table 2 the main characteristics in the Nyakapenda River Valley. The similarities are quite prominent and in general may be expressed as follows. The Sporites are the most prominent taxa in the assemblages. The Triletes are abundant but the Monoletes are represented by only one genus: *Schizosporis*. Within the Pollenites the Monosaccites are important but the Disaccites, exclusive of *Vesicaspora*, are insignificant. The Colpates are restricted to the Middle seam in the Mchuchuma River Valley and the middle and upper part of the Lower seam in the Nyakapenda River Valley.



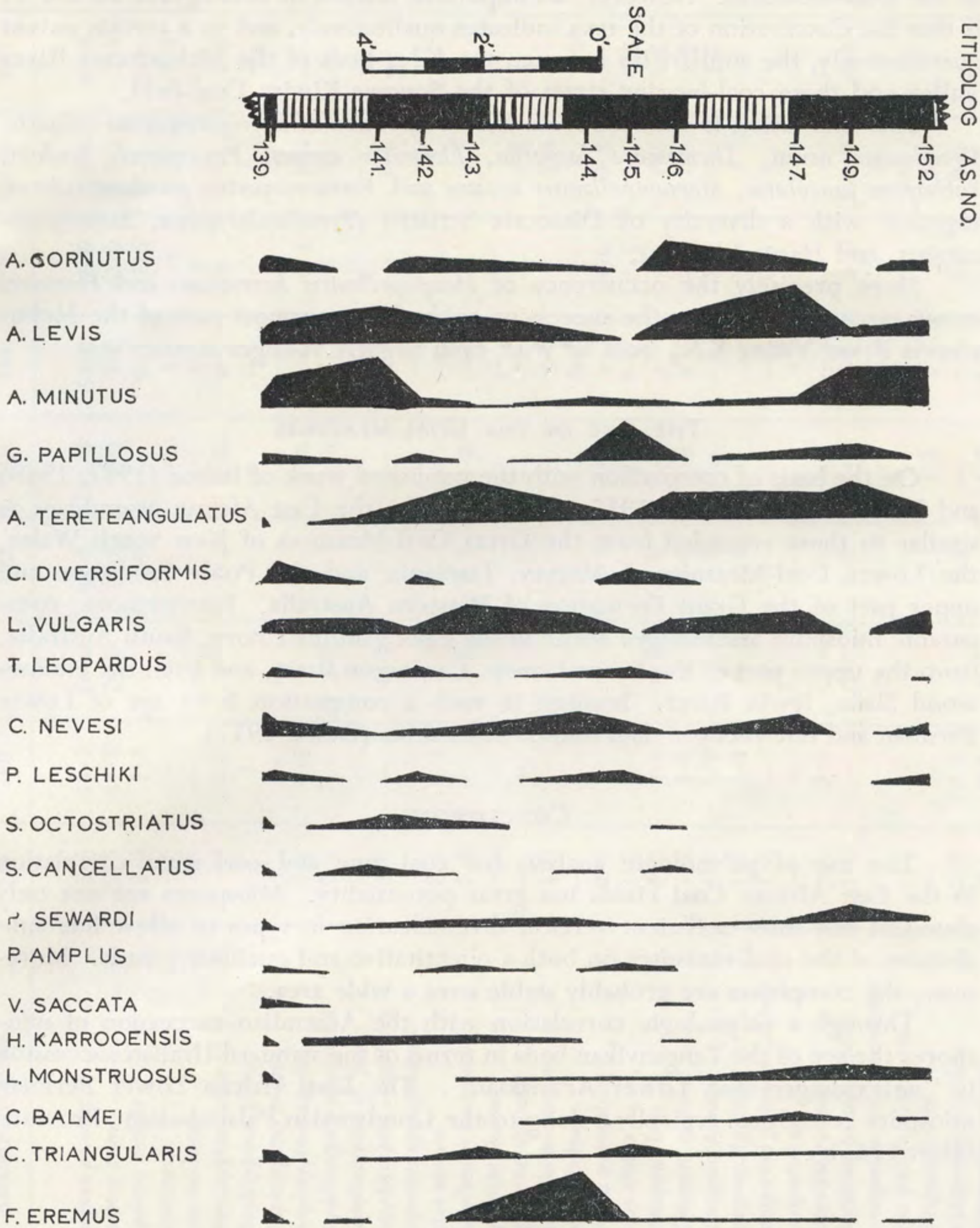
Text-figure 56

This parallelism in the sequences of miospore assemblages indicates that palynologic analysis has great potential value as a means of locating and exploiting the Tanganyikan Coal-measures. A comparison between the two seams from the Nyakapenda and any of the coals from the rest of the measures does not show a similar pattern.

The Songwe-Kiwira Coal-field Palynologic Complex

The results of the investigations into the Songwe-Kiwira coal-measures are given in text-figures 56 and 57, and table 3. An examination of figure 56 indicates that Pollenites are the main components in the microflora, forming 65-95% of the total assemblage. Within this taxon the Saccites are most prominent (30-82%) with the Monosaccites and Colpates persistent but not abundant.

On the other hand the Sporites usually form less than 20% of the total



Text-figure 57

assemblage: but may extend up to 45% in odd samples. The Triletes are well represented and the Monoletes occasionally common (0-4%).

The quantitative distribution of individual species and genera throughout the succession is of little importance at the present stage in the investigation of the Coal-measures. However, an important feature of text-figures 56 and 57 is that the distribution of the taxa indicates qualitatively, and to a certain extent quantitatively, the similarities between the $K2e_2$ beds of the Mchuchuma River Valley and these coal-bearing strata of the Songwe-Kiwira Coal-field.

This conclusion is deduced from the occurrence of *Laevigatosporites vulgaris*, *Cycadopites nevesi*, *Thymospora leoparda*, *Florinites eremus*, *Pityosporites leschiki*, *Pakhapites fasciolatus*, *Marsupipollenites striatus* and *Verrucosisporites pseudoreticulatus;* together with a diversity of Disaccate Striatiti (*Protohaploxypinus*, *Striatopodocarpites*, and *Hamiapollenites*).

More precisely the occurrence of *Hamiapollenites karrooensis* and *Florinites eremus* tentatively equates the succession with the uppermost part of the Mchuchuma River Valley $K2e_2$ beds or with even slightly younger strata.

The Age of the Coal-measures

On the basis of comparison with the published work of Balme (1957, 1959) and Balme and Hennelly (1955, 1956a, 1956b) the East African assemblage is similar to those recorded from the Greta Coal-Measures of New South Wales, the Lower Coal-Measures of Mersey, Tasmania, and the Poole Sandstone and upper part of the Grant Formation of Western Australia. Furthermore, comparable miospore assemblages occur in the Lake Phillipsia Bore, South Australia, from the upper part of the Lyons Group, Carnarvon Basin, and from the Holmewood Shale, Irwin River. Implicit in such a comparison is an age of Lower Permian and not younger than middle Artinskian (Balme 1957).

Conclusions

The use of palynologic analysis for coal-zone and coal-seam correlation in the East African Coal Fields has great potentiality. Miospores are not only abundant but show sufficient vertical diversification in types to allow fine subdivision of the coal-measures on both a quantitative and qualitative basis. Moreover, the complexes are probably stable over a wide area.

Through a palynologic correlation with the Australian succession of miospores the age of the Tanganyikan beds in terms of the standard Uralian succession is "not younger than Lower Artinskian". The East African Lower Permian miospore complexes typically belong to the Gondwanian Palaeobotanic Province (Hart 1965b).

TABLE III

Percentage Distribution of species through the Coal-Measure succession exposed at Ilima Colliery

ASSEMBLAGE No.	139	140	141	142	143	144	145	146	147	149	152
Taxon:											
Vesicaspora potoniei	35·5	14·5	46·0	48·0	42·0	55·0	16·0	25·6	67·0	41·0	48·0
Vesicaspora ovata	20·5	58·5	20·0	14·0	9·0	7·0	62·0	7·2	5·0	33·0	26·0
Pityosporites leschiki	2·0	1·5	—	1·0	—	0·5	1·0	—	—	—	2·0
Pityosporites sp.	—	—	—	—	—	r	—	—	1·0	—	r
Pityosporites rarus	—	—	—	—	—	r	r	—	—	—	—
Protohaploxypinus sewardi	r	—	?	1·0	1·0	0·5	r	?	1·0	1 0	1·0
Protohaploxypinus globus	—	?	—	—	—	—	—	r	—	—	r
Protohaploxypinus micrus	r	—	—	?	—	—	—	—	—	—	1·0
Protohaploxypinus amplus	0·5	0·5	—	—	1·0	—	0·5	0·4	—	—	—
Striatopodocarpites octostriatus ..	0·5	—	2·5	r	1·0	—	—	?	—	—	—
Striatopodocarpites cf. fusus	—	—	?	—	—	—	—	—	—	—	?
Striatopodocarpites cancellatus ..	1·5	—	0·5	?	—	r	—	0·8	—	—	—
Lueckisporites nyakapendensis	—	—	—	—	—	—	?	—	—	—	—
Vittatina saccata	0·5	0·5	—	—	—	—	—	?	—	—	—
Hamiapollenites karrooensis	1·0	—	1·0	0·5	1·0	—	—	r	—	—	—
Vestigisporites balmei	—	—	—	—	—	—	—	?	—	—	—
Vestigisporites thomasi	—	—	?	—	—	—	—	0·8	—	—	—
Limitisporites monstruosus	1·0	—	—	—	r	?	r	0·8	r	1·0	1·0
Cordaitina balmei	—	—	—	—	—	0·5	?	?	1·0	—	—
Cordaitina triangularis	0·5	r	—	0·5	1·0	r	1·0	0·8	—	r	—
Florinites eremus	1·5	—	r	—	?	9·0	1·5	r	1·0	—	2·0
Apiculatisporis levis	1·0	3·5	6·0	5·0	6·0	r	—	7·2	9·0	0·5	1·0
Apiculatisporis cornutus	1·5	2·0	—	2·0	3·5	r	—	11·2	1·0	—	1·0
Apiculatisporis minutus	4·0	3·0	—	1·5	—	—	1·0	r	1·0	3·5	5·0
Calamospora nigretella	1·5	3·0	—	1·5	—	—	1·0	r	—	—	—
Punctatisporites gretensus f. minor ..	1·0	—	—	?	—	—	0·5	r	—	—	—
Punctatisporites sp.	—	—	—	—	—	?	—	—	—	—	—
Neoraistrickia ramosa	r	0·5	?	—	—	—	—	r	—	—	—
Acanthotriletes tereteangulatus	1·5	—	2·0	6·0	11·0	3·0	0·5	12·0	4·0	4·0	0·5
Verrucosisporites pseudoreticulatus ..	—	—	—	—	—	—	—	r	—	—	—
Verrucosisporites cf. trisectus	—	—	—	—	—	—	—	—	?	—	—
Deltoidospora directa	—	—	—	—	1·5	r	?	10·4	?	—	?
Granulatisporites papillosus	2·0	0·5	—	1·5	—	r	4·0	0·8	—	1·0	—
Laevigatosporites vulgaris	r	0·5	0·5	r	3·5	2·0	—	3·2	3·0	—	2·0
Thymospora leoparda	?	0·5	—	1·0	—	0·5	0·5	0·4	—	—	?
Cycadopites nevesi	6·0	3·5	r	1·5	1·5	5·0	1·0	0·8	3·0	—	0·5
Marsupipollenites striatus	—	—	—	r	r	r	—	0·8	—	—	—
Pakhapites fasciolatus	2·0	r	—	—	—	—	—	—	—	—	—

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KEY TO TEXT-FIGURES

Figure 51
Location map of the Tanzanian Coalfields.

Figure 52
Synopsis of Miospore distribution through the lower coal-measures exposed in the Mchuchuma River Valley.

Figure 53
Distribution of main species through the Mchuchuma River Valley succession.

Figure 54
Distribution of main species through the Mchuchuma River Valley $K2e_1$ thick coal-seams.

Figure 55
Distribution of main species through the Nyakapenda River Valley $K2e_1$ thick coal-seams.

Figure 56
Distribution of major taxa through the Songwe-Kiwira coal-seams exposed at Ilima colliery.

Figure 57
Distribution of main species through the Songwe-Kiwira coalfields exposed at Ilima colliery.

TABLE II

Percentage Distribution of Species in the thick coals of the Nyakapenda River Valley

Assemblage Number	65	67	69	70	71	72	73	74	75	77	80	82	83	84	86	88	89	95	96	97	98	99	100	101	102	103	104	105
Taxon:																												
Vesicaspora potoniei	—	—	—	0·5	2·0	4·0	3·0	2·0	?	1·0	—	—	—	—	—	—	—	—	—	—	—	—	—	?	?	6·0	5·0	?
V. ovata	7·0	18·0	6·0	3·5	16·0	8·0	6·0	6·5	13·5	4·0	1·0	3·0	2·0	?	—	r	—	31·0	25·1	9·0	28·0	r	r	6·8	4·0	10·0	33·0	4·4
V. sulcata	1·0	1·0	—	?	r	?	?	—	?	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
Protohaploxypinus sewardi	—	—	—	—	0·4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	?	—	r	—	r
P. amplus	—	—	—	—	—	—	—	—	0·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lueckisporites nyakapendensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	r	0·1	r	—	—	—
Vittatina saccata	—	—	?	1·0	4·0	0·4	3·0	4·0	2·0	0·5	—	—	—	—	—	0·8	r	r	r	r	r	4·8	3·4	7·6	6·4	—	1·0	?
Vestigisporites balmei	—	?	—	—	—	0·4	—	—	0·5	—	—	—	—	—	—	—	—	r	r	—	—	—	—	—	1·0	—	—	—
V. cf. rudis	—	—	—	—	—	?	—	—	—	—	—	—	?	—	—	—	—	r	?	—	—	—	—	r	1·0	—	—	—
V. methoris	—	—	—	—	?	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—
V. hennellyi	—	1·0	—	—	—	?	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
V. thomasi	—	?	—	—	?	—	—	—	1·0	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2·4
Limitisporites monstruosus	—	?	—	0·5	r	0·4	—	1·0	0·5	—	—	—	2·0	—	—	—	—	?	r	—	?	—	?	r	—	—	?	—
Cordaitina balmei	—	—	—	0·5	1·2	—	—	—	1·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	3·2	2·0	4·0	5·6
C. triangularis	—	3·0	2·0	5·0	10·4	6·4	2·0	3·0	4·0	—	—	—	2·0	2·0	—	2·0	2·0	8·0	4·0	r	1·6	10·0	30·5	7·6	14·2	?	3·0	10·8
Apiculatisporis levis	6·5	4·0	9·0	10·0	1·6	3·2	7·0	24·0	19·0	15·0	12·0	—	5·0	12·0	8·0	10·0	7·5	r	6·4	r	r	20·4	16·0	22·0	23·2	58·0	38·0	10·0
A. cornutus	3·0	1·0	8·0	r	3·6	6·0	4·0	—	5·0	6·0	13·0	10·5	18·0	r	—	46·4	61·0	10·0	7·6	r	4·8	6·0	1·4	22·4	2·0	6·0	12·0	25·2
A. minutus	6·5	—	2·0	0·5	0·4	0·4	—	2·0	—	?	5·0	4·0	10·5	12·0	r	2·8	7·0	—	—	—	—	—	—	—	—	—	—	—
C. nigretella	—	1·0	—	1·5	r	0·8	—	—	r	—	1·0	—	—	—	—	0·8	—	—	—	—	r	—	r	1·0	1·0	—	—	1·6
C. sp. "A".	—	2·0	—	—	—	?	—	7·0	—	—	—	—	—	—	—	—	—	2·9	5·5	r	r	9·6	3·5	1·0	1·0	—	—	?
Punctatisporites gretensis forma minor	12·5	7·0	24·0	5·0	9·2	13·2	16·0	—	10.5	21·0	31·0	7·0	14·5	19·0	14·0	34·8	20·5	18·0	3·2	r	5·8	24·4	21·2	10·6	15·8	9·0	6·0	23·6
Neoraistrickia ramosa	1·0	—	—	?	0·4	—	3·0	—	2·0	8·0	—	—	—	—	—	—	—	r	r	—	—	4·8	r	5·2	1·2	2·0	—	—
Acanthotriletes tereteangulatus	?	—	—	—	—	—	—	—	0·5	—	—	—	—	—	—	—	—	—	—	—	—	—	?	r	2·0	—	—	?
Daltoidospora giganta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	r	—	r	1·0	r	1·0	—	—	—	—
Granulatisporites papillosus	44·5	10·0	46·0	66·0	19·6	18·4	33·5	45·0	33·5	36·0	35·0	10·0	36·5	50·0	4·0	—	—	3·0	13·1	4·4	16·0	4·0	5·5	6·8	13·2	—	—	—
Zinjisporites eccensis	9·5	40·0	—	—	13·2	27·5	19·5	—	—	r	1·0	62·5	6·5	?	40·0	—	—	r	18·0	77·0	16·8	r	—	—	—	—	—	—
Z. zonata	1·0	2·0	—	—	3·2	2·0	1·0	—	—	—	—	1·0	—	—	20·0	—	—	—	1·0	2·0	r	—	—	—	—	—	—	—
Cirratriradites africanensis	—	—	—	—	?	—	—	3·0	—	—	—	—	—	—	—	—	—	—	r	—	7·8	r	—	—	—	—	—	—
Schizosporis scissus	—	—	—	—	—	—	—	—	1·0	—	—	—	—	?	4·0	—	—	—	—	—	r	?	—	r	1·2	—	—	1·0