

Palynology of Lower and Middle Pennsylvanian Coal Beds in the Central Appalachian Basin: Paleobotanic and Biostratigraphic Implications



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System	Series	Western Europe Series	Mid-continent USA Series	WV Groups & Formations	Eastern Kentucky Groups	Eastern Kentucky Formations	Miospore Assemblage Zones			West Virginia Coal Beds & <i>widespread marine zones</i> (Eastern Kentucky equivalents)										
							1	2	3											
Pennsylvanian	Late	Stephanian	Virgilian	Monongahela		Monongahela	NBM	TT		Redstone										
			Missourian	Cone-maugh		Cone-maugh	ST	LM		Pittsburgh										
		MO							Little Clarksburg											
	Asturian	Desmoinesian	Allegheny		Princess	OT	GM	PD _s	Elk Lick											
							CP	PD _t	<i>Ames Marine Lst + Shale</i>											
	Bolsovian	Atokan	Kanawha		Four Corners	SL	MI	SG _k	Harlem											
							RD	SG _b	Bakerstown											
	Duckmantian		Hyden		SF				<i>Brush Creek Marine Lst + Shale</i>											
										Brush Creek (Princess 10)										
	Early	Langsettian	Morrowan	New River	Breathitt	Pikeville	NJ	NG	VA	Mahoning										
										Grundy	RA	SR	RS	Upper & Lower Freeport (Princess 8 & 9)						
														Alvy Crk.			Lower & Middle Kittanning / No. 6 Block (Princess 6 & 7)			
																	Bottom Creek	SS		No. 5 Block (Princess #5,5a,5b, Richardson, Skyline)
																				Poca-hontas
		Yeadonian		Poca-hontas	KV			Stockton "A"												
								Kinder-scoutian					<i>Kanawha Black Flint (Stoney Fork Member)</i>							
																Stockton (Broas, Hazard # 9, 10)				
																				Coalburg (Peach Orchard, Hazard # 7, 8)
						<i>Winifrede Shale Member (Magoffin Member)</i>														
												Chilton (Taylor, Copland)								
												Fire Clay, Fire Clay Rider								
												Cedar Grove (Whitesburg)								
												<i>Dingess Shale Member (Kendrick Shale Member)</i>								
												Williamson (Amburgy)								
												<i>Campbell Creek Limestone (Elkins Fork Shale)</i>								
												No. 2 Gas/Pearless (Upper Elkhorn # 3)								
												Powellton (Upper Elkhorn # 1 & 2)								
												<i>Crummies Member (Cannelton ls)</i>								
												Eagle (Pond Creek)								
												<i>Betsie Shale</i>								
												Matewan (Manchester)								
												Glenalum Tunnel (Splash Dam)								
												Gilbert (Elswick / Barren Fork)								
												laeger (Tunnel, Stearns)								
												Castle								
												Sewell								
												Little Raleigh								
												Beckley								
												Fire Creek (Cumberland Gap?)								
												Little Fire Creek								
												Pocahontas No. 9								
												Pocahontas No. 8								
												Pocahontas No. 6 & 7								
												Pocahontas No. 5								
												Pocahontas No. 4								
												Pocahontas No. 3								
												Pocahontas No. 1 & 2								
												Squire Jim								

Palynologic Zonations: 1) Clayton et al., 1977, 2) Peppers, 1985, 3) Ravn, 1986

Series	Western Europe Series	Mid-continent USA Series	WV Groups & Formations	Eastern Kentucky Groups	Eastern Kentucky Formations	Miospore Assemblage Zones	
						1	2
Early Pennsylvanian		Morrowan		Breathitt	Grundy	RA	SR
	Langsetian				Alvy Crk.		
	Yeadonian				Bottom Crk.	SS	LP
	Marsdenian		Pocahontas		Pocahontas	FR	
	Kinder-scoutian	KV					

West Virginia Coal Beds &
widespread marine zones
 (Eastern Kentucky equivalents)

Betsie Shale Member

Matewan (Manchester)

Gladeville SS (Corbin SS)

Lower War Eagle (Hagy)

Glenalum Tunnel (Splash Dam)

Gilbert (Elswick / Barren Fork)

laeger (Tunnel, Stearns)

Hensely Member

Sewell A, B

Sewell

Fire Creek (Cumberland Gap?)

Dark Ridge Member

Pocahontas No. 9

Pocahontas No. 8

Pocahontas No. 6 & 7

Pocahontas No. 5

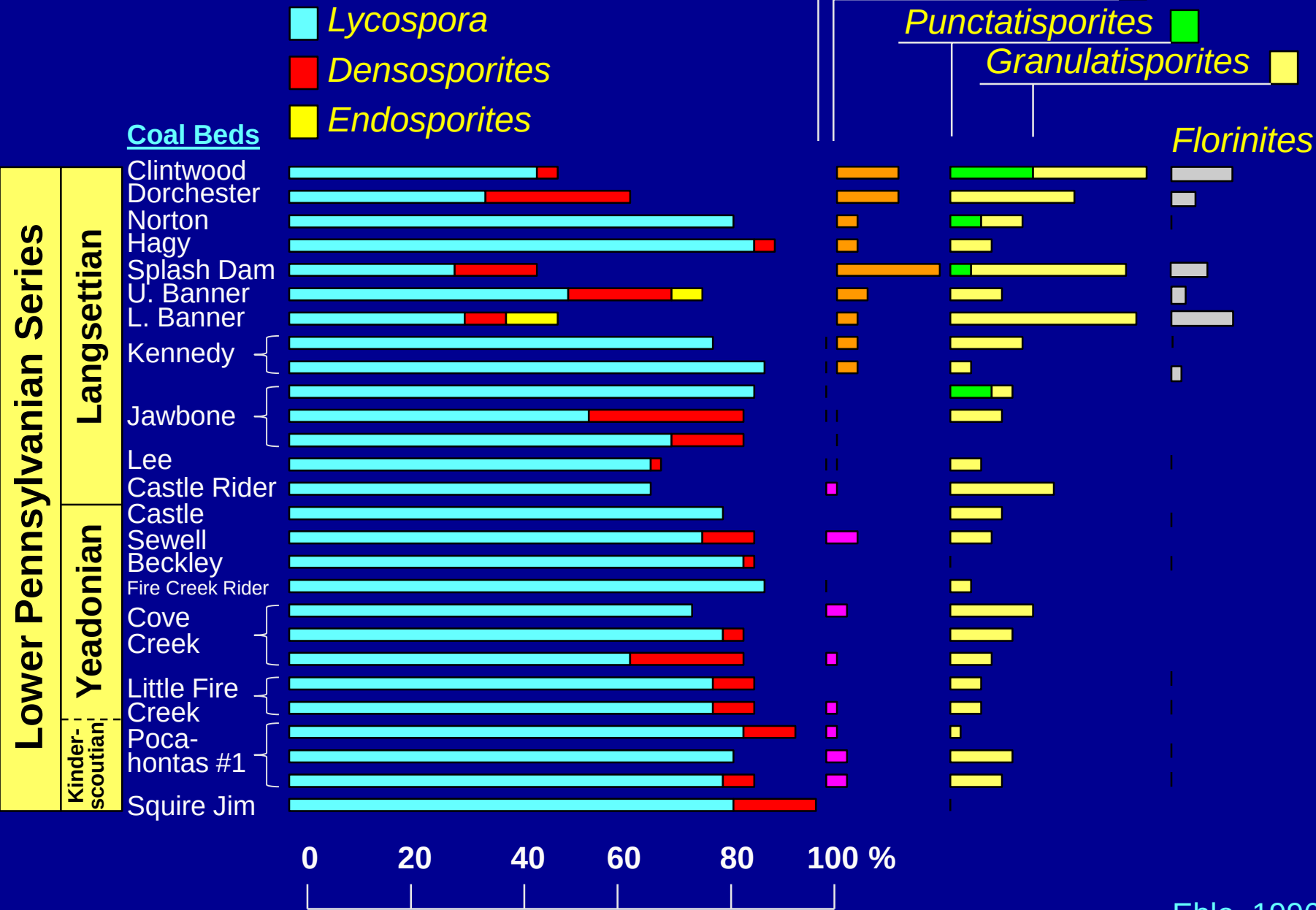
Pocahontas No. 4

Pocahontas No. 3

Pocahontas No. 1 & 2

Palynologic Zonations: 1) Clayton et al., 1977, 2) Peppers, 1985

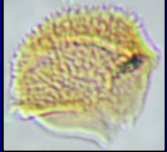
Early Pennsylvanian



Langsetian		RA		SS		KV		FR	
Clintwood Blair Dorchester <i>Gladeville sandstone</i> Hagy Splash Dam Upper Banner Lower Banner Kennedy <i>Naese sandstone</i> <i>Bee Rock sandstone</i> Jawbone Tiller Upper Seaboard Greasy Creek Middle Seaboard Lower Seaboard Upper Horsepen Middle Horspen War Creek									
Yeadonian	Pocahontas #9 Pocahontas #8								
Marsdenian	Pocahontas #7 Pocahontas #6 Pocahontas #5								
-----	Pocahontas #4 Pocahontas #3 Pocahontas #2 Pocahontas #1								
Kinder-scoutian	Squire Jim								



Schulzospora rara



Anaplanisporites baccatus



Dictyotriletes bireticulatus



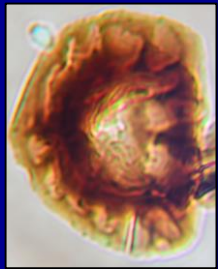
Granasporites medius



Laevigatosporites

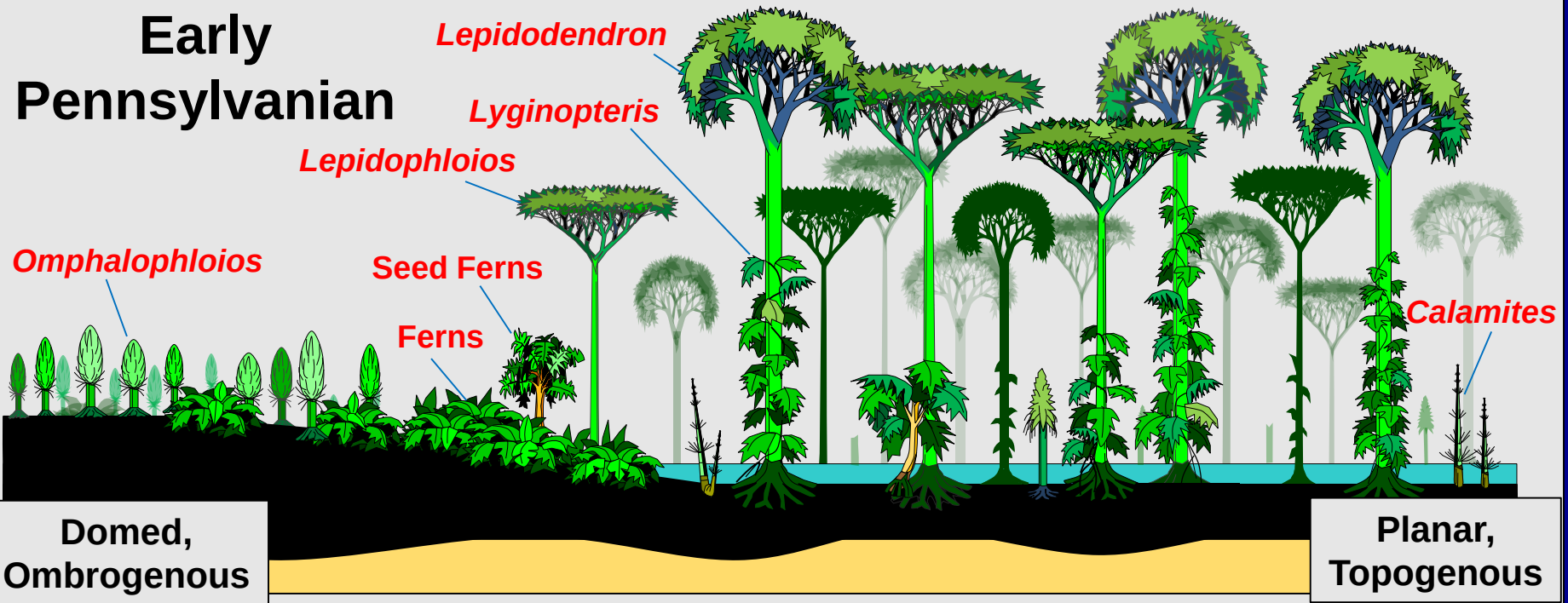


Endosporites



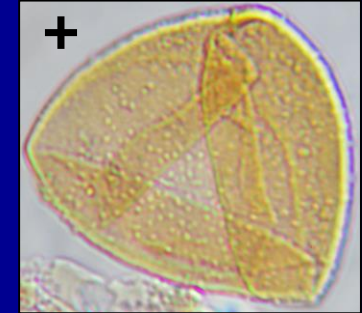
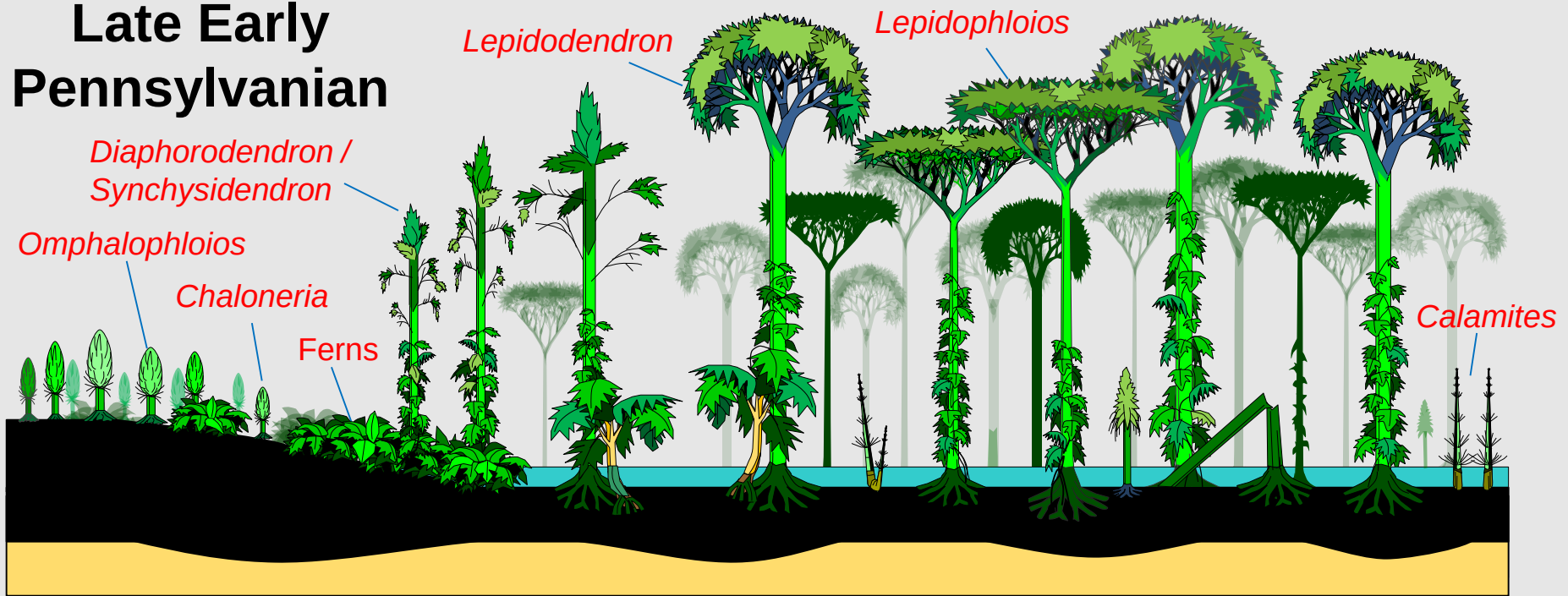
Radiizonates Aligerans-striatus

Early Pennsylvanian



- Palynofloras are usually dominated by *Lycospora* (*Lepidophloios*, *Lepidodendron*, and *Paralycopdites*).
- “Densospores” (*Densoporites*, and related genera produced by *Omphalophloios*) are subdominant, both within and between, coal beds.
- Small Fern (e.g., *Granulatisporites*), and calamite spores (*Calamospora*) are common accessory taxa.
- Lyginopterid seed fern (*Schulzospora*) and cordaite pollen (*Florinites*) are consistently seen in minor amounts.

Late Early Pennsylvanian



Locally Abundant

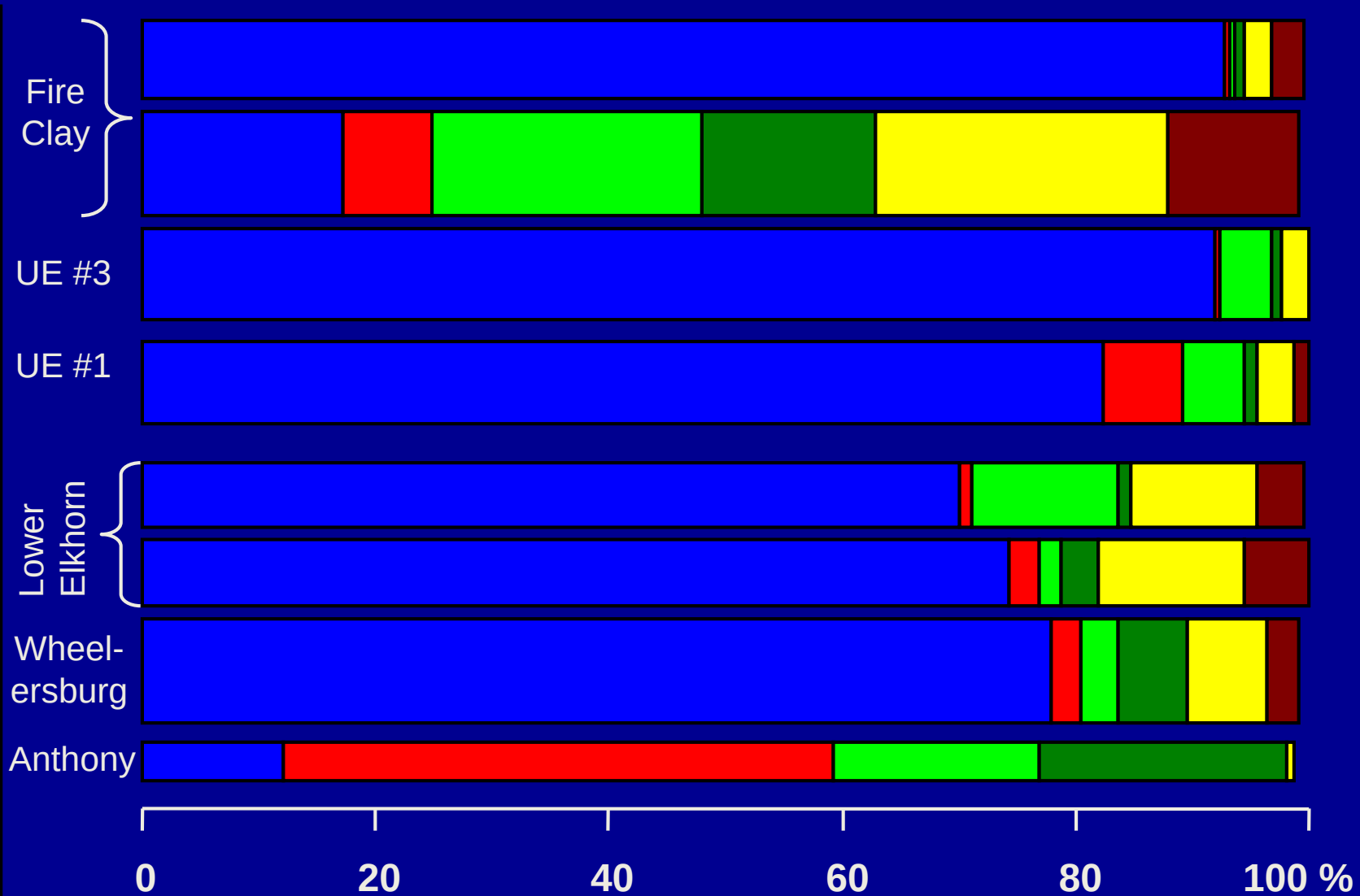


Cordaite Pollen
(Florinites)

Series	Western Europe Series	Mid-continent USA Series	WV Groups & Formations	Eastern Kentucky Groups	Eastern Kentucky Formations	Miospore Assemblage Zones 1 2		West Virginia Coal Beds & widespread marine zones (Eastern Kentucky equivalents)
Middle Pennsylvanian	Duckmantian	Atokan	Kanawha	Breathitt	Hyden	SL	SF	Winifrede (Magoffin) Shale Mbr. Chilton (Taylor, Copland) Fire Clay Rider Fire Clay Cedar Grove (Whitesburg)
					Pikeville	NJ	NG	Dingess (Kendrick) Shale Mbr. Williamson (Amburgy) Campbells Crk. (Elkins Fork) No. 2 Gas (Up. Elkhorn # 3) Powellton (Up. Elkhorn # 1 & 2) Crummies Member Eagle (Lower Elkhorn)
	Atokan	Kanawha	Breathitt	Hyden	Pikeville	SL	SF	Betsie Shale Member

Palynologic Zonations: 1) Clayton et al., 1977, 2) Peppers, 1985

Middle Pennsylvanian			
Morrowan	Atokan		
Langsettian	Duckmantian		
Grundy Fm	Pikeville Formation	Hyden Fm	



cm
0
40



Duckmantian

SL

NJ

Winifrede (Magoffin) Shale Mbr.

Chilton (Taylor, Copland)

Fire Clay Rider

Fire Clay

Cedar Grove (Whitesburg)

Dingess (Kendrick) Shale Mbr.

Williamson (Amburgy)

Campbells Crk. (Elkins Fork)

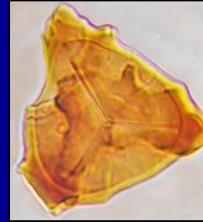
No. 2 Gas (Up. Elkhorn # 3)

Powellton (Up. Elkhorn # 1 & 2)

Crummies Member

Eagle (Lower Elkhorn)

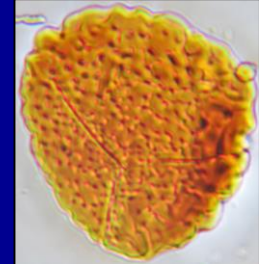
Betsie Shale Member



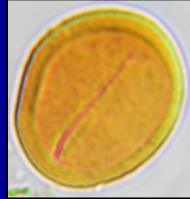
Triquitrates sculptilis



Vestispora fenestrata

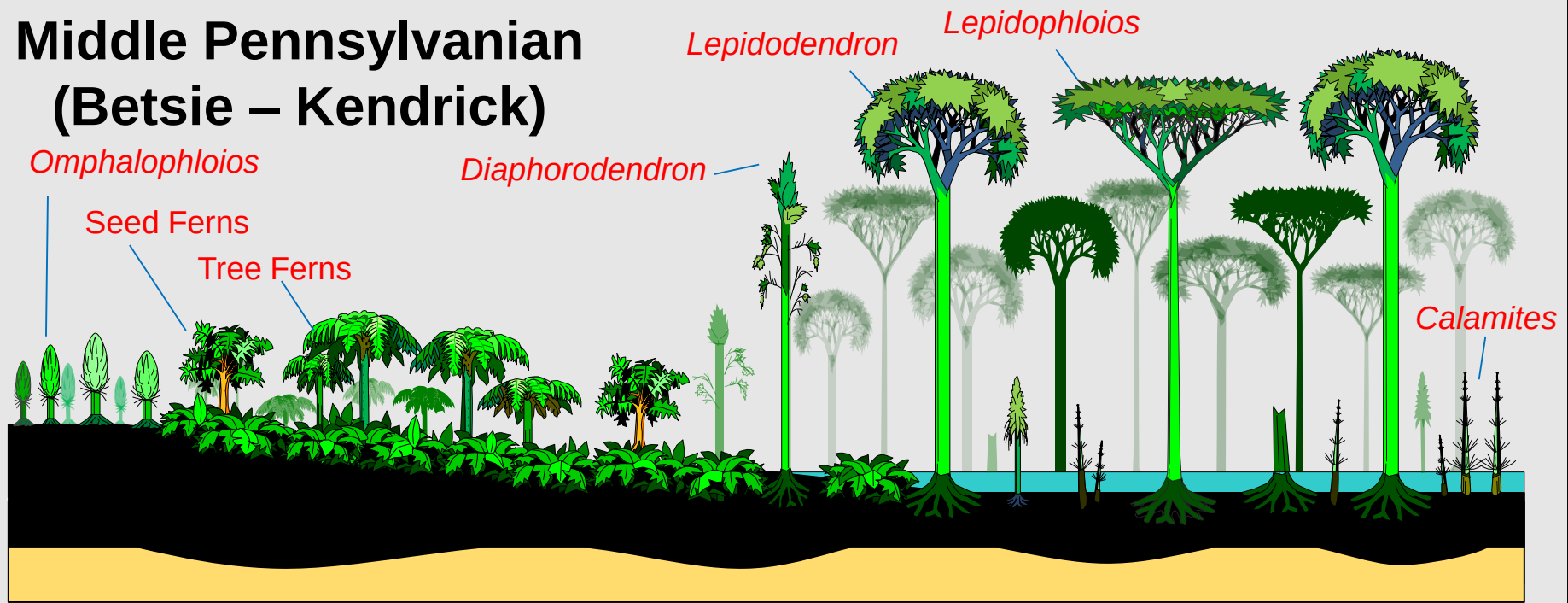


Microreticulatisporites sulcatus



Laevigatosporites globosus

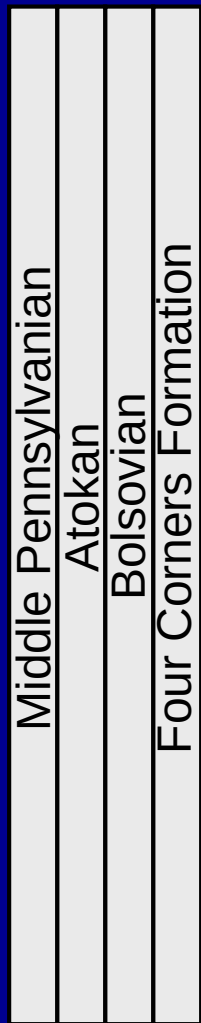
Middle Pennsylvanian (Betsie – Kendrick)



- Palynofloras are usually dominated by *Lycospora* (*Lepidophloios*, *Lepidodendron*, and *Paralycopdites*).
- “Densospores” (*Densoporites*, and related genera produced by *Omphalophloios*) are locally abundant, both within and between, coal beds.
- Tree fern spores (*Punctatisporites minutus* and *Punctatosporites minutus*) become more abundant.
- Cordaite pollen (*Florinites*) become abundant in the Taylor coal (just below the Winifrede (Magoffin Member) marine zone).

Series	Western Europe Series	Mid-continent USA Series	WV Groups & Formations	Eastern Kentucky Groups	Eastern Kentucky Formations	Miospore Assemblage Zones		West Virginia Coal Beds & <i>widespread marine zones</i> (Eastern Kentucky equivalents)										
						1	2											
Middle Pennsylvanian	Bolsovian	Atokan	Kanawha	Breathitt	Princess	MI	RA	SL Winifrede (Magoffin) Shale Mbr.										
									Desmoinesian	Charleson SS / Allegheny	CP	OT	Brush Creek Limestone Mbr. Brush Creek (Princess No. 10) Mahoning Upper Freeport (Princess No. 9) Lower Freeport (Princess No. 8) Middle Kittanning (Princess No. 7) LK / No. 6 Block (Princess No. 6) No. 5 Block Little No. 5 Block (Richardson) Stockton "A" (Skyline) KBF (Stoney Fork Shale Mbr.) Stockton (Hazard # 9, 10) Coalburg (Hazard # 7, 8) Winifrede (Haddix, Hazard)					
														Asturian	MO	GM		
	Late	Stephanian	Virgilian	Cone-maugh		Cone-maugh												

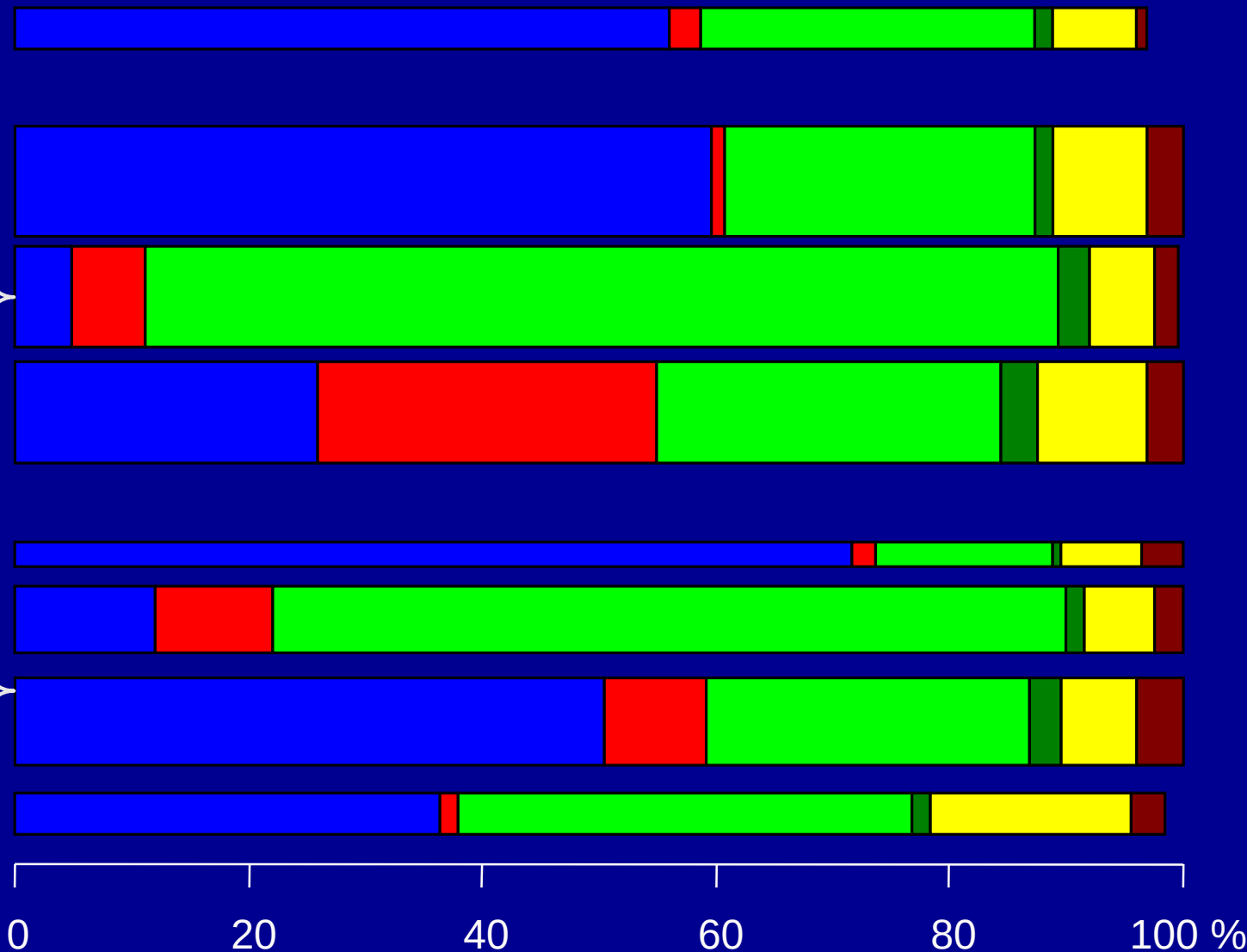
Palynologic Zonations: 1) Clayton et al., 1977, 2) Peppers, 1985



Princess
No. 4
(Hzd. 9)

Princess
No. 3B
(Hzd. 8)

Princess
No. 3A
(Hzd. 8)



cm

0

40

Lycopod Trees

Small Lycopods

Tree Ferns

Small Ferns

Calamites

Cordaites

Stephanian	OT	
Asturian		
Bolsovian	SL	

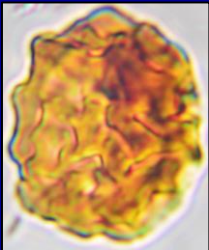
Brush Creek Limestone Mbr.

Brush Creek (Princess No. 10)
 Mahoning
 Upper Freeport (Princess No. 9)
 Lower Freeport (Princess No. 8)
 Middle Kittanning (Princess No. 7)
 LK / No. 6 Block (Princess No. 6)
 No. 5 Block
 Little No. 5 Block (Richardson)
 Stockton "A" (Skyline)

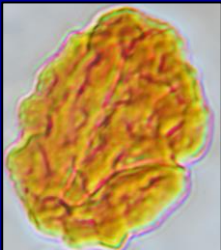
KBF (Stoney Fork Shale Mbr.)

Stockton (Hazard # 9, 10)
 Coalburg (Hazard # 7, 8)
 Winifrede (Haddix, Hazard)

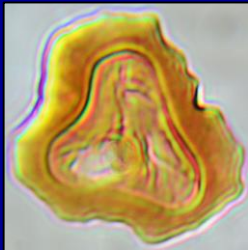
Winifrede (Magoffin) Shale Mbr.



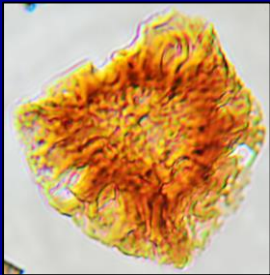
*Thymospora
pseudothiessenii*



*Thymospora
obscura*

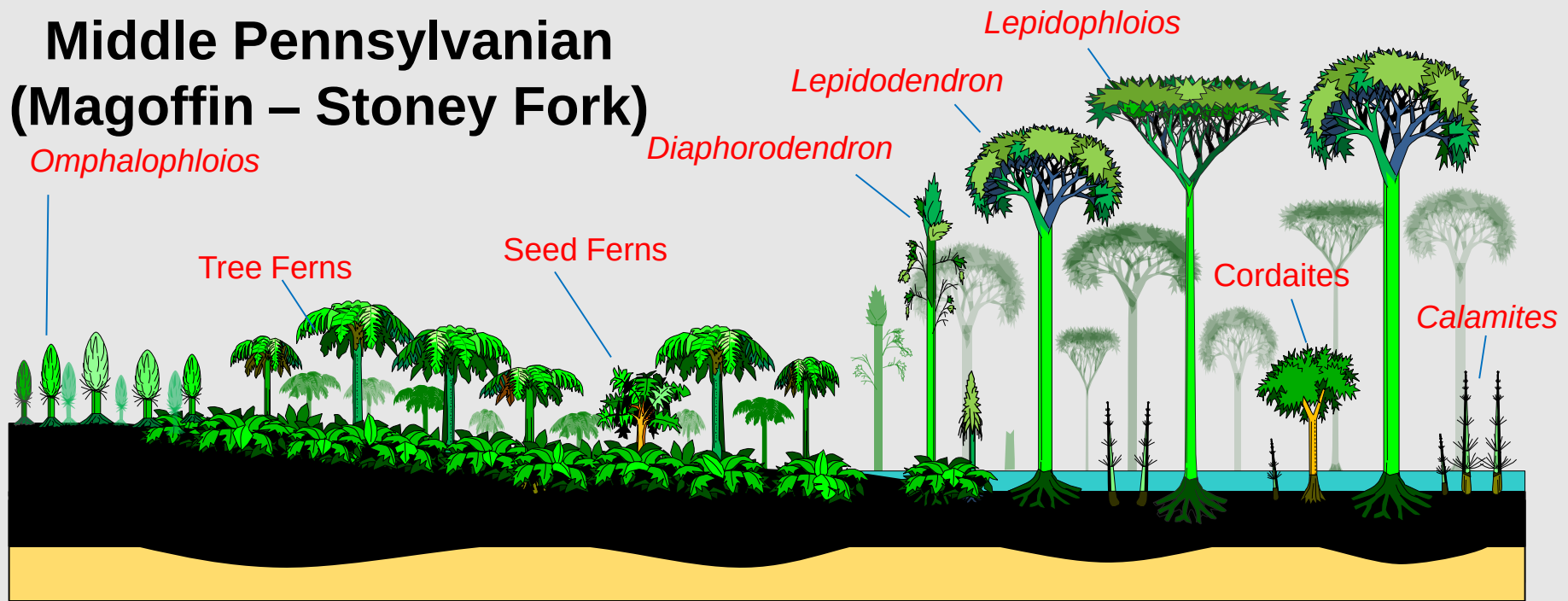


*Murospora
kosankei*



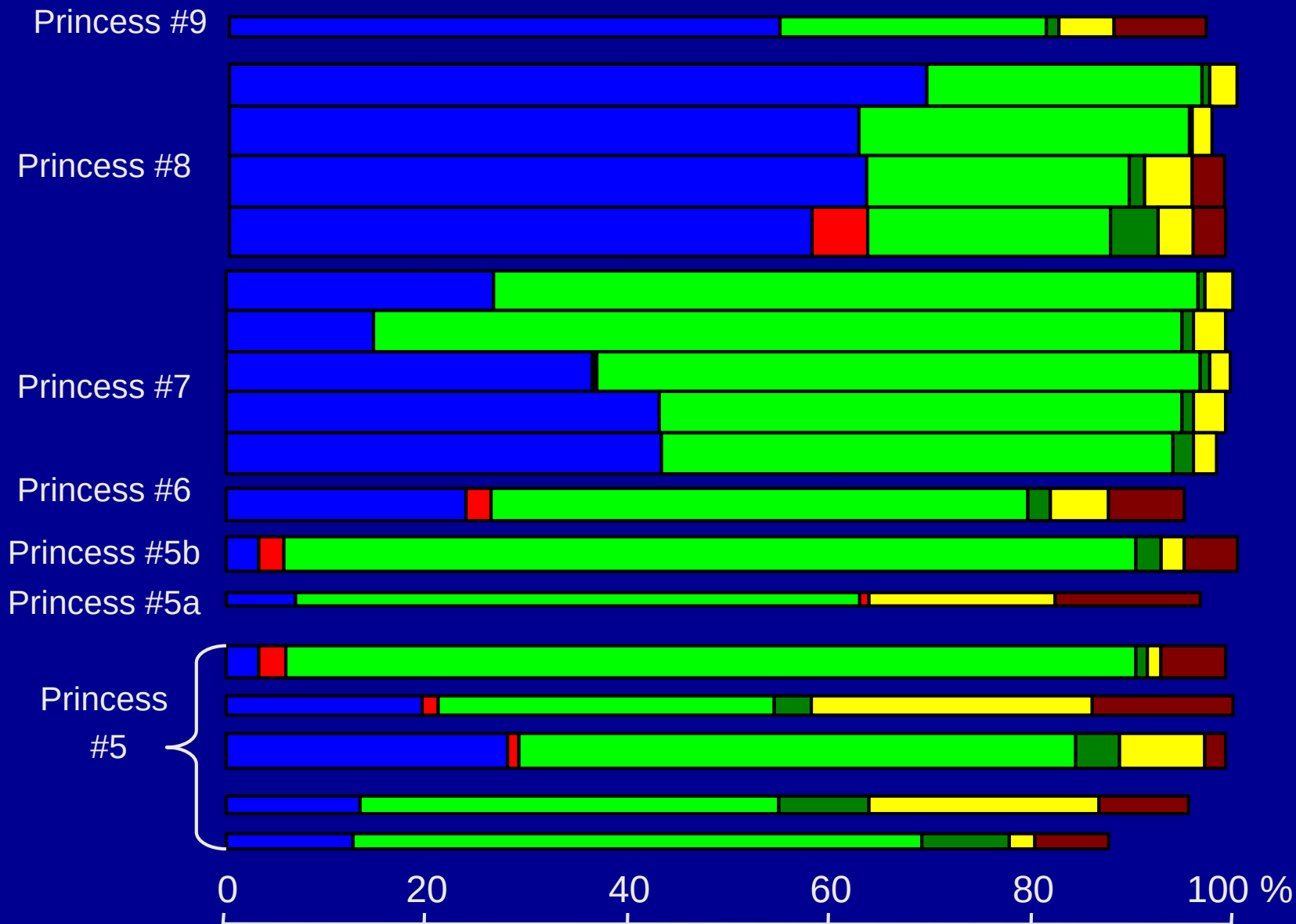
*Radizonates
difformis-
rotatus*

Middle Pennsylvanian (Magoffin – Stoney Fork)



- Palynofloras are typically co-dominated by *Lycospora* (*Lepidophloios*, *Lepidodendron*, and *Paralycopdites*), and tree fern spore taxa.
- “Densospores” (*Omphalophloios*) are locally abundant, both within and between, coal beds. *Radiizonates difformis* originates in, and in part defines, this interval.
- Small Fern (e.g., *Granulatisporites*), and calamite spores (*Calamospora* + *Laevigatosporites* spp.) are common accessory taxa.
- Cordaite pollen (*Florinites*) shows local abundance.

Middle Pennsylvanian	
Desmoinesian	
Princess Formation	
Asturian	
Atokan	
Bolsovian	



0.00
0.15
0.30
0.45

Steph-anian	OT
Asturian	
Bolsovia	SL

Brush Creek Limestone Mbr.

Brush Creek (Princess No. 10)
Mahoning

Upper Freeport (Princess No. 9)
Lower Freeport (Princess No. 8)
Middle Kittanning (Princess No. 7)
LK / No. 6 Block (Princess No. 6)
No. 5 Block

Little No. 5 Block (Richardson)
Stockton "A" (Skyline)

KBF (Stoney Fork Shale Mbr.)

Stockton (Hazard # 9, 10)

Coalburg (Hazard # 7, 8)

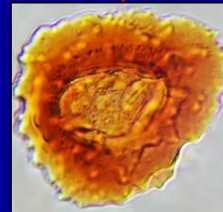
Winifrede (Haddix, Hazard)

Winifrede (Magoffin) Shale Mbr.

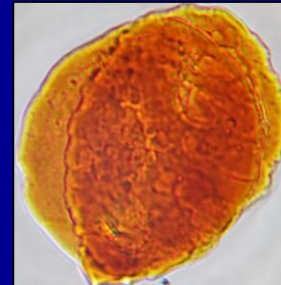
Densosporites
spp.



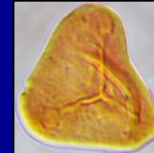
Dictyotriletes
bireticulatus



Schopfites dimorphus



Triquitrites
minutus



Cadiospora
magna

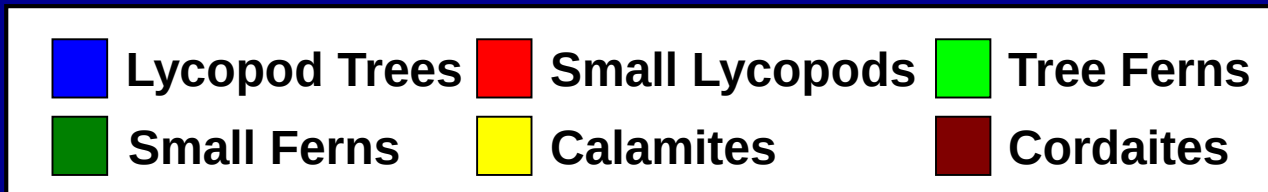
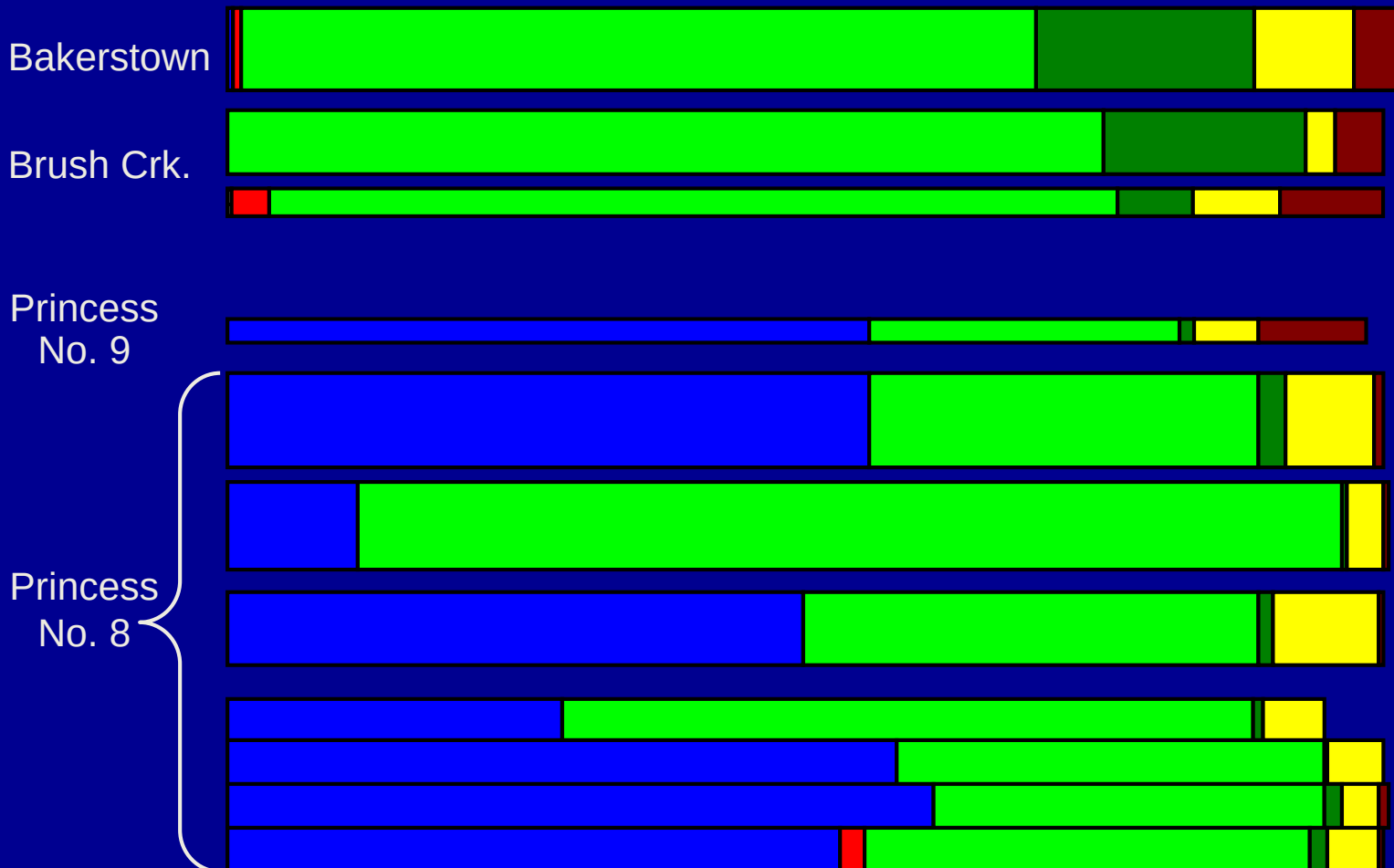


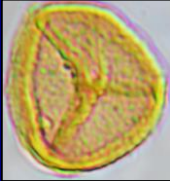
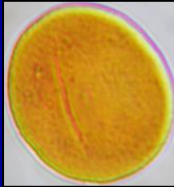
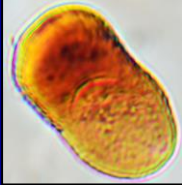
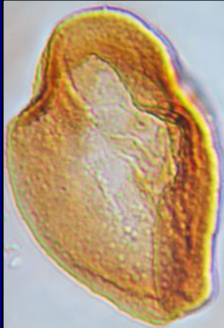
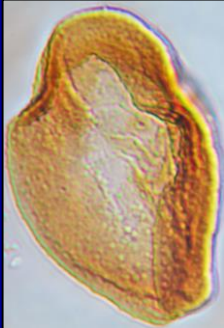
Late Middle Pennsylvanian (Stoney Fork – Brush Creek)



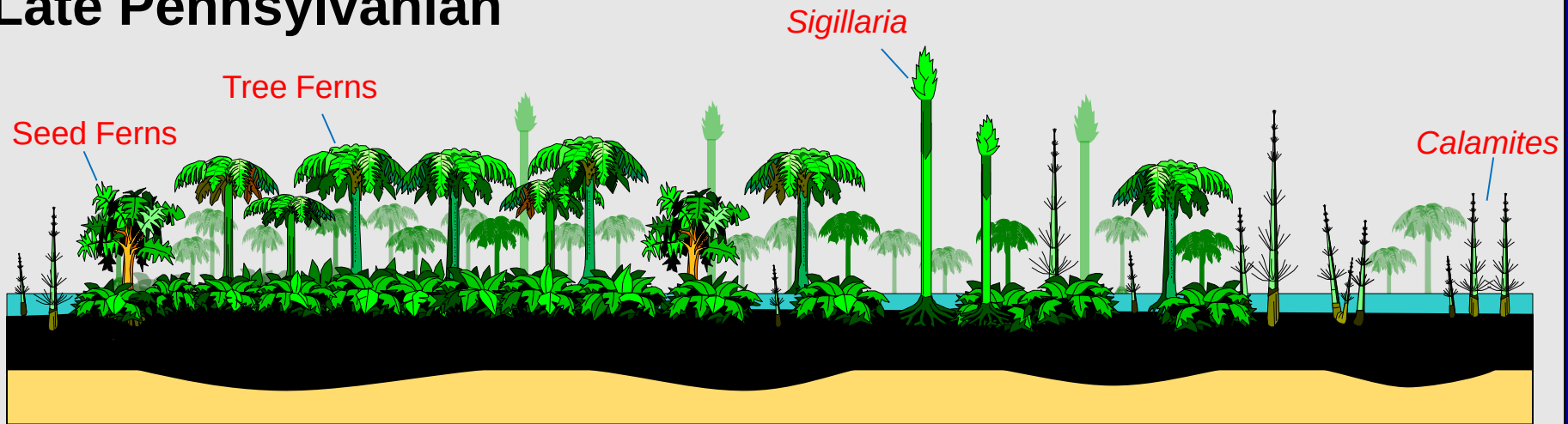
- Palynofloras are typically co-dominated by *Lycospora*, and tree fern spore taxa. Tree fern spores reach maximum diversity. *Thymospora pseudothiessenii* and *T. obscura* (Asturian index taxa) are first seen in the #5 Block coal zone.
- “Densospores” (*Densosporites*, *Radiizonates*, etc., produced by *Omphalophloios*) are last seen in the Princess #6 coal bed.
- Small Fern (e.g., *Granulatisporites*), and calamite spores (*Calamospora* + *Laevigatosporites* spp.) are common accessory taxa.
- Cordaite pollen (*Florinites*) shows local abundance.

Middle Pennsylvanian	Late Penn
Desmoinesian	Missourian
Asturian	Stephanian
Princess Formation	Conemaugh



Steph-anian	OT	Brush Creek Limestone Mbr. Brush Creek (Princess No. 10) Mahoning Upper Freeport (Princess No. 9) Lower Freeport (Princess No. 8) Middle Kittanning (Princess No. 7) LK / No. 6 Block (Princess No. 6) No. 5 Block Little No. 5 Block (Richardson) Stockton "A" (Skyline)	 <i>Lycospora</i> spp.	 <i>Granasporites</i> medius	 <i>Laevigatosporites</i> globosus	 <i>Torispora</i> securis	 <i>Crassispora</i> kosankei
Bolsovian	SL	KBF (Stoney Fork Shale Mbr.) Stockton (Hazard # 9, 10) Coalburg (Hazard # 7, 8) Winifrede (Haddix, Hazard) Winifrede (Magoffin) Shale Mbr.	 <i>Lycospora</i> spp.	 <i>Granasporites</i> medius	 <i>Laevigatosporites</i> globosus	 <i>Torispora</i> securis	 <i>Crassispora</i> kosankei

Late Pennsylvanian



- Late Pennsylvanian palynofloras are devoid of *Lycospora*. *Crassispora kosankei* (*Sigillaria*) is the only lycopod tree genus that occurs in the Late Pennsylvanian.
- Small lycopods are represented by *Endosporites* (*Chaloneria*), which is locally abundant both within, and between, coal beds.
- Small Fern (e.g., *Granulatisporites*), and calamite spores (*Calamospora* + *Laevigatosporites* spp.) are common accessory taxa.
- Cordaite pollen (*Florinites*) is common, and locally abundant. Seed fern (*Schopfipollenites*), and conifer (e.g., *Potonieisporites*) pollen occur more consistently.

Summary

- Spore and pollen floras from Pennsylvanian coal beds in the Central Appalachian Basin are useful for biostratigraphic identification and correlation, and also as a proxy for paleoecological reconstruction.
- Early Pennsylvanian palynomorph assemblages are usually dominated by *Lycospora*, with *Densosporites* being subdominant in many assemblages. Spores and pollen from other plant groups are typically minor by comparison, though local abundance is not uncommon.
- Middle Pennsylvanian coal palynofloras show a progressive increase in tree fern spores in an older to younger direction. The top of the Middle Pennsylvanian marks the termination point of several taxa, most notably *Lycospora*.
- Late Pennsylvanian coals are markedly different in palynologic composition, being dominated by tree fern spore taxa.

