CHAPTER FIVE

SUMMARY AND CONCLUSIONS
This thesis describes some of the intraseam and lateral variation within the miospore flora at several localities (Fig. 5.1 and Fig. 5.2) in the Springfield and Herrin Coals of the Illinois Basin. Since the miospore samples were collected adjacent to coal-balls, variation in the palynological profiles were also compared to seam profiles of plant macrofossils found in permineralized peat (coal-balls). Because most previous investigations of these coals used channel (whole seam) samples, this thesis includes the first reports of fine-scale vertical variation of miospores in these coal seams from coal-ball areas.

Major Findings

The detailed profiles of this study indicate the palynological history of the seam from a number of localities. These profiles can be tied to the more extensive palynological information based on seam averages. Based on these palynological profiles, along with comparison to coal-ball profiles and paleobotanical information about the coal plants, a number of findings were noted:

1. Comparison of miospore and coal-ball profiles shows a broad correlation between miospore changes and changes in vegetation in the coal balls, especially in the Herrin.

2. In contrast to the Herrin’s fairly uniform flora, profiles from the Springfield Coal showed more differences in swamp vegetation at different localities (Chapter 2). When this information was published (Mahaffy, 1985), it was the first report of this variation based on miospore profiles. The findings fit both with earlier reports of regional variation in the Springfield based on channel samples and coal-ball profiles (Peppers, 1970;
Phillips, Peppers, and DiMichele, 1985) and a recent and more extensive miospore profile study (Willard, 1993).

3. Differences in abundance and composition of miospore taxa at different levels of the seam are distinct enough that vegetational phases can be defined using these changes in the two detailed profiles (Site 1 and 2) from the Old Ben mine (Fig. 4.3 and 4.4) and one from Sahara (Fig. 3.2).

4. Miospore changes were also correlated with changes in lithotype of the coal and with five preservation categories of the miospores (excellent to very poor). Changes in spore preservation often occurred when major miospore changes took place, resulting in some vegetational phases of distinctively poor spore preservation, while others in the same profile showed excellent preservation.

5. The amount of variation in miospores from a limited area was established with extensive sampling from one of the localities in the Herrin (Old Ben 24 locality - Chapter 4). At this locality the same vegetation stages could be distinguished in two seam profiles (Chapter 4; Figures 4.3 and 4.4) separated by 381 meters, even though relative abundance for many miospores differed.

6. In both coals, the miospore flora from localities proximate to the major contemporaneous paleochannels showed differences from the flora elsewhere. The differences in near-channel vegetation are more pronounced in the Springfield Coal (Chapter 2) than in the Herrin.

7. In some cases miospore patterns suggest different kinds of ecological constraints for some
of the miospore-producing taxa. One of the major tree-fern miospores, *Thymospora*, shows a different pattern than some of the other tree-fern miospores especially at Sahara where it rises to second in abundance in the top zone at 29 percent. *Thymospora* is less abundant (less than 16 percent for any zone) in the two most complete profiles from Old Ben (Sites 1 and 2), but at both Sahara and Old Ben, this miospore shows less rapid changes in abundance than the two other miospores produced by *Psaronius*. This pattern might be interpreted as a tree fern that occupied less disturbed sites (Chapter 2).

**Palynological History Of Peat Deposits (Vertical Profiles)**

Miospore changes within the seam were used to subdivide the profiles from both seams into vegetational phases. The Herrin Coal changes are highlighted here since, with this coal’s more uniform palynological flora, our profiles should be representative of general changes that occurred in the coal swamp elsewhere, more representative, at least, than would be the case in the Springfield Coal (See Chapter 2).

In the Herrin Coal a number of profiles were prepared from two localities, (Sahara - Chapter 3 and Old Ben - Chapter 4). Overall miospore profiles from both localities show a general similarity. At both localities, *Lycospora* (mainly from *Lepidophloios*) dominates the bottom two thirds of the seam, accounting for about half the miospores found in the seam average: 43-58% at Old Ben sites and 54% at the Sahara site (Table 4.4). Tree-fern miospores, which are second in abundance (19-32% at Old Ben; 32% at Sahara), dominate the seam above this *Lycospora* zone. As is the case of their source plants in coal-ball profiles (DiMichele and
Phillips, 1988), spores associated with the tree-fern *Psaronius* tend to increase when *Lycospora granulata* (from *Lepidophloios*) decreases. Also at both localities the miospore from *Granasporites*, which is restricted to portions of the seam, is found in most of the increments of a distinctive top zone (Fig. 4.9). In the coal-ball profiles from the Old Ben locality, the source plant of this miospore is also found as a distinctive zone of *Diaphorodendron* (DiMichele and Phillips, 1988).

**Effect Of Near-Channel Environment**

**Herrin Coal**

Within this general similarity of a lower portion of the seam dominated by *Lycospora* and an upper portion dominated by tree-ferns, some distinct differences can be seen between profiles from the Sahara (Chapter 3) and Old Ben (Chapter 4) locality. These differences may be caused in part by the Old Ben locality being in an environment close (11km) to the major freshwater channel of this coal swamp, the Walshville (Fig. 5.1).

Seam averages (channel samples) show some of the greatest changes in miospore flora from localities close to this paleochannel, with *Lycospora* increasing from 65% to 85% near the channel (Phillips et al., 1985) indicating a somewhat different environment. A comparison of profiles from the two localities shows that the miospore phases in the Sahara profile are more distinct and extend over a greater portion of the seam than they do at Old Ben 24. The difference is evident especially in the vertical pattern of distribution of the tree-fern spore, *Thymospora*, which forms a distinctive zone in the upper portion of the seam at Sahara (Fig. 3.1;
Chapter 3), but not at Old Ben 24, where other tree fern spores are more important (Fig. 4.4 and 4.3). These variations suggest that environmental differences associated with the different miospore phases may have been more pronounced and lasted longer, with less fluctuation, at the Sahara locality. Coal lithotypes and spore preservation categories, both of which could have been affected by the original environmental conditions, also show sharper changes at Sahara. The central *Lycosphora* zone at Sahara, for instance, shows consistently poor spore preservation, while the same zone at the Old Ben locality shows the entire range of spore preservation types - from good to very poor. Perhaps the near-channel environment of the Old Ben locality was subject to more flooding or other near-channel effects; while at the Sahara locality, more distant from the channel, environmental conditions could have been more stable for a longer period. These variations might explain why there is a distinct miospore flora high in *Thymospora* at Sahara in a portion of the seam low in clastics (also low in durain) and not at the Old Ben locality. One possibility might be that the tree ferns that produced *Thymospora* developed better on a peat (possibly non-topogenous) less affected by floods from the channel.

The upper portion of the seam, where *Thymospora* shows its peak, is also distinctive in the coal-ball profiles from the Sahara locality (Phillips and DiMichele, 1981). The coal-ball flora is more diverse flora than the earlier flora that was heavily dominated by *Lepidophloios* and is interpreted by Phillips and DiMichele (1981) as a “successively drier sequence of vegetation” (p.258), which lacks the amount of standing water favorable for *Lepidophloios* dominated stands.

Clastic bands are prominent at Sahara and mark major changes in both coal-ball data
(Phillips and DiMichele, 1981) and in a miospore profile (Fig. 3.1). At the Old Ben locality vegetation changes are less prominent at clastic bands except for the “blue band,” where a dramatic drop (20-6%) occurs in tree-fern miospores (Fig. 4.8). The “blue band” is thought to represent an over-the-bank splay deposit of a major flood event (Johnson, 1972).

**Springfield Coal**

In the Springfield, like in the Herrin, the miospore patterns from localities (Fig. 5.2) in a near-channel environment were quite different from the locality distant from the channel (Chapter 2). The near-channel environments were even more distinctive in the Springfield than were near-channel environments in the Herrin.

The near-channel sampling in the Springfield was done in the vicinity of the Leslie Cemetery Channel, a distributary of the main Galatia channel. This distributary was active during only part of the time of coal deposition, being abandoned or becoming much less active before the end of the coal swamp (Eggert, 1982a, 1982b). Two seam profiles were collected from the channel area. One was collected from the coal just before it split at Spur Mine, while the other sampled the top split of the rider coal, 800 meters away. As in the case in the Herrin, *Thymospora* is more abundant throughout the profile at the locality (Burning Star) distant from the channel (Fig. 2.2) and, with a seam average of 34.5 percent, is about as abundant as *Lycospora*. *Thymospora* is about half as abundant (17.3 percent) at the Spur Mine close to the Leslie Cemetery Channel, but this lower percentage in the seam average is due almost entirely to its absence or low percentages in the coal in the upper half. *Thymospora* is rare in the upper
coal split from the same area. Another miospore that is less abundant in the profiles closer to the channel is *Anapiculatisporites spinosus*. This miospore represents a smaller herbaceous lycopod (Baxter, 1971). Both *Anapiculatisporites spinosus* and *Endosporites globiformis* (the miospore of another herbaceous lycopod *Chaloneria*) seem to be under strong local swamp control, based on their distribution pattern (from Peppers, 1970) in other Spoon and Carbondale Formation coals (Table 2.2). While some other miospores increase in abundance in coals closest to the epibole coal of these formations, these miospores show a pattern of being abundant in only some coals around the epibole coal and often not the adjacent coals. This suggests the distribution of these lycopods is affected by local conditions not present in all coal swamps.

The coal split on top of the channel shows a very distinct miospore flora, high in lycopod spores (mainly *Lycospora*) and with half the number of tree ferns (Table 2.1). Very little of the miospore signature of the contiguous unsplit coal (Fig. 2.3) can be found in the flora of the upper split (Table 2.1 and Fig. 2.4). Coal overlying the channel may represent a time transgressive facies for this coal, with its unique flora formed after deposition had ceased in the unsplit coal 800 meters away. Perhaps the coal was deposited by an isolated coal swamp that developed on the abandoned channel and levees of the Leslie Cemetery Channel in an otherwise degrading delta. Later workers (Willard *et al*., 1995) have found marine conodonts in coal-balls of this upper bench, suggesting an atypical (for the Springfield) marine influence during or soon following deposition of this upper coal member.
Miospore Variation In A Local Area

Extensive sampling for patterns of miospore deposition from a local (smaller) area was done at the Old Ben 24 mine. Here the room and pillar mining method of operation allowed collecting from pillars in any direction from any other sample, and placement of coal sampling from within or adjacent to the coal-ball masses. By locating samples under different kinds of roofs, we were also able to see if the coal palynoflora changed with the roof lithology (see Chapter 4).

At this mine two detailed columns were collected of the exposed seam from two sites, 381 meters apart. Comparison of profiles from these two columns (Chapter 4), along with additional coal samples from specific levels of the seam like the "blue band," form the basis for evaluating the amount of lateral variation in miospores over short distances. Using changes in abundance, as well as presence or absence of taxa, miospore patterns within the seam can be quite precisely matched at this distance. With the exception of the very top coal, which was more variable, even the less distinct vegetational phases can be discerned at both sites. In fact, most individual coal samples could be matched between the two sites allowing us to subdivide the seam (Chapter 4) into seven zones that represent equivalent times of deposition at both sites.

The abundance of important spores (*Lycospora granulata, Thymospora pseudothiesseni*) or groups of spores (tree-fern spore and large species of *Laevigatosporites*) are compared from the two detailed columns profile (Fig. 5.3-5.6) using their average abundance in each of the seven zones. The similarity of the patterns is in many cases striking and more obvious in these
zone comparisons than in the comparison of the profiles based on all the increments (Figs. 4.3 and 4.2). Perhaps an averaging effect smooths some of the minor fluctuations making the similarity in patterns more obvious in the comparisons based on seven subdivisions. With the exception of Thymospora, the miospores plotted all show very similar changes in abundance at the corresponding levels, as can be seen in the strong linearity of their ratios displayed on a scatter plot in the same figures (Fig. 5.3 - 5.6). In fact, a linear regression analysis for the Lycospora pattern indicates that 80 percent ($R^2 = 0.79669$) of the variance among the ratios can be accounted for in a straight line. Of these spores, Thymospora shows quite variable ratios or differences in patterns ($R^2 = 0.05009$), although this variation is caused almost entirely by two of the middle zones (4 and 5) and variation in the zone 7 above the “blue band” and not at the top. The variation may be a bit higher in 7 because the very bottom of this zone could not be collected from one of the profiles. While Thymospora shows a variable pattern, the pattern of combined tree fern spores is much closer ($R^2 = .41625$).

Although many of the patterns are very similar, comparison of the profiles from sites 1 and 2 show that some strong local variation can be detected at this distance. Perhaps this variation is best seen in comparing the patterns (using all increments) of the four miospores of the Psaronius source plant (Fig. 4.8). At both sites tree-fern spores are abundant at similar levels of the seam, but different Psaronius spores are responsible for the pattern at each site. Punctatosporites minutus is twice as abundant at one site; while at the other site, with less P. minutus, another Psaronius miospore, Thymospora, is more abundant. Since at each site a different tree-fern spore is much more abundant for much of the profile, different Psaronius
types are closer to one than the other site. Perhaps microenvironmental conditions, such as topography or water flow patterns, persisted long enough to sustain different stands of *Psaronius* for considerable periods of time in the original coal swamp. Correlating these different *Psaronius* miospore patterns to coal-ball data is still difficult, because there is not always a one-to-one correlation between miospores, or even organs, and well defined stems in coal-balls (Lesnikowska, 1989). While some progress has been made in correlation, several species of *Psaronius* produce the same miospore (Lesnikowska, 1989).

The distribution patterns of some spores (such as *Endosporites globiformis* and *Crassispora*) suggest a somewhat patchy distribution of the plants producing these spore. These spores occur at approximately the same position in different seam profiles, but not in the same abundance or exact pattern in the various profiles. Although present elsewhere in the coal-swamp at that time as indicated by their presence is some profiles, stands or individuals of this plant were not close enough to some sites to have had many or in some cases any of their miospores found in other profiles. *Endosporites globiformis*, the miospore of one of the small herbaceous lycopods, *Chaloneria*, found at the top of the seam is the best example of such a pattern. Similar patterns for both *Crassispora* (source plant *Sigillaria*) and *Granasporites* (*Diaphorodendron*) also suggest a similar patchy distribution of parent plant stands.

In addition to the two profiles, samples were compared from the same level of the coal at Old Ben from a number of different sites. For this comparison of lateral variation, the “blue band” provided a reference point to insure that coal samples from different sampling sites represent equivalent times of deposition. A number of miospore taxa showed markedly similar
patterns of change across the "blue band" at all sites (Table 4.2). For instance *Punctatosporites minutus* increases, *Laevigatosporites globosus* drops sharply at the "blue band" (11.2-0.3% at one site), and *Punctatisporites* (large spp.) also decreases in relative percentage right at the "blue band." The seam profiles show that one of the biggest changes in miospore percentages occurs at the “blue band,” and this comparison shows that these changes were similar throughout this mine locality. The flood deposit that produce this “blue band” significantly disrupted the vegetation and produced marked and similar changes in vegetation at all the sites sampled in this locality. Tree-fern spores are one miospore group that shows changes at this level of the seam.

One tree-fern spore, *Punctatosporites minutus*, increases immediately above the blue band; another *Laevigatosporites globosus* drops sharply at the "blue band" (11.2-0.3% at Site 1) and then increases in relative abundance immediately above it. *Punctatisporites* (large spp.) also decreases in relative percentage right at the "blue band" (Site 1 from 27.7-3.7%).

**Comparison Of Miospore And Coal-ball Vegetation**

A major purpose of this thesis was to relate the two most common means used for analyzing the vegetation of these Middle Pennsylvanian coals by comparing the palynological to coal-ball analysis from the same localities. A number of issues can be addressed by relating the palynological data of this study to information from vegetation analysis of coal balls.

One was to compare the similarity of the miospore flora of coal balls to the miospore flora of the surrounding coal. This was done by extracting miospores from the coal-ball layers at the Sahara locality and comparing them to the palynology of the surrounding coal (Table
5.1. The patterns produced by miospores from the coal-balls (Fig. 3.3) are generally similar to patterns of the same miospores extracted from the coal (Fig. 3.1 and 3.2). On a whole seam basis, the peat (coal-ball) taxa are very similar to the same taxa in the coal (Table 5.1), as are similarity indices (Whittaker, 1975) based on all the taxa (Table 5.2). This strongly suggests that the process of coalification did not affect much of a change in the miospore flora from the time of coal-ball formation in the early stages of peat formation. The similarity of coal-ball to coal palynology has also been subsequently confirmed by Klare’s (1987) finding of a high correspondence between spores from within coal-balls to the palynology of the coal from on the outside of the same coal balls from an Iowan Coal (Blackoak?).

Our study also helps establish the usefulness of projecting coal-ball vegetation to the swamp more broadly by ruling out the possibility that the palynology (floristics) of the coal immediately around the coal-ball mass was different. Knowing that coal miospores in coal-ball pods were similar to palynology of the coal elsewhere at a locality lends more validity to using coal-ball profiles as representative of the original swamp at that locality.

Comparisons between coal miospores and peat are still valid only if coal miospores and coal-balls both represent the same local swamp vegetation that produced the peat. In some depositional environments, a larger component of spores can represent the regional and perhaps distant non-coal swamp flora. The miospore flora of some shales probably represents such a non-local flora (Neves, 1961), but this should not be the case for miospores produced from within a swamp. Modern vegetation studies (Janssen, 1973; Tauber, 1977) indicate that in such an environment the miospore flora would represent vegetation of the immediate vicinity, with a
The comparisons between intraseam variation of peat and miospores were helpful for both the palynology and peat analysis. Peat patterns from the limited number of coal-ball sites can now be generalized to the coal elsewhere, wherever coal palynology samples are available. For the palynology, permineralized vegetation from coal balls provides a reference to tie miospores changes to their source plants deposited in the coal, and can even provide a rough indicator of the over- or under-representation of individual taxa in the palynoflora (Table 5.3). Having the coal-ball vegetation as reference is especially helpful since, unlike Quaternary workers, Carboniferous palynologists can not compare their fossil miospore patterns to miospore rain from some modern ecosystem that includes source plants for the fossil miospores they are studying. The only other macrofossil that could be used as a reference for the miospores would be compressions usually found above the coal in the roof shales. The compression flora are less useful for comparison than the coal-ball flora since they often represent a clastic swamp somewhat different from the coal swamp (DiMichele et. al. 1996). Moreover, transport occurs more frequently in compression floras sometimes resulting in an allochthonous flora transported from vegetation at some distance (Gastaldo, Pfefferkorn, and DiMichele 1995).

### Comparisons Between Amount Of Miospores And Amount Of Source Plants In Coal Balls

In this thesis comparisons are made both of intraseam patterns and a more quantitative comparison of the amount of miospores to the biovolume of the litter of their source plants. Calculating the over- or under-representation of miospores to their source plants is now possible
since the taxonomic affinities of most of the miospores of these coals is now known.

Percentages of miospores and some of their source plants are shown on a whole seam basis from both the Sahara and Old Ben localities (Table 5.3) in the Herrin. These percentages give only as an approximate value of over- or under-representation and are probably valid only for comparisons on an averaged whole-seam basis. Comparing miospores to their source plants from the same level of the seam to an adjacent coal-ball layer should not have a seam averaging effect, but it is often hard to assure that exactly the same layers are being compared.

Seam ratios have also been show to vary substantially in other coals with the same miospores and source plants (DiMichele et al., 1996). Still, some generalizations can be made for a number of plants, such as *Granasporites*, almost always under-representing its source plant, *Diaphorodendron*, by a large amount and *Lycospora granulata* almost always over representing the amount of *Lepidophloios*. Because of the variation, these figures should be taken only as an indication of the approximate over- or under- representation of miospores from these localities. Finding similarities or differences in patterns of miospore and coal-ball profiles may be as helpful as ratios of the amount of over- or under- representation.

**Comparison Of Intraseam Patterns In Both Miospore And Coal-ball Profiles**

The best locality to compare spore and peat profiles is the Old Ben locality, where two detailed profiles of coal miospores (Fig. 4.3 and Fig. 4.4) can be compared with one of the most detailed coal-ball profiles ever collected (21 layers of coal balls above the “blue band” from one sampling site (VS 3) - DiMichele and Phillips, 1988). A comparison shows that the same major
changes recorded in the palynological profiles also occur in the coal-ball vertical profile 3-5 (Fig. 6, DiMichele and Phillips, 1988). In almost all cases, a major increase in any coal-ball plant taxon is matched by a miospore increase at the same level of the seam. For instance, in both cases there is greater abundances of tree ferns at three levels (below the “blue band,” above the “blue band,” and just below the top of the seam) although the tree-fern abundance is less pronounced in the coal-ball profiles than in the miospore profiles. At least above the blue band, these tree ferns alternate with levels high in lycopods (*Lepidophloios* above the blue band). One of the more distinctive vegetation changes also occurs in the coal-balls from the top where an assemblage high in *Diaphorodendron*, “pteridosperms, lycopsids, tree ferns, and ground cover” (p. 118) can be found (DiMichele et al. 1996). Palynologically this top zone is also a distinctive zone (Fig. 4.9) that includes the *Diaphorodendron*’s miospore *Granasporites* and *Endosporites globiformis* (the miospore of another herbaceous lycopod *Chaloneria*).

There are also some differences between the coal-ball vegetation and miospores samples. Sometimes a plant found in both miospore profiles shows up at the same level in only one of the coal-ball profiles. This finding can be illustrated by the distribution of *Sigillaria* and its miospore *Crassispora* in the profiles. In both of the palynological profiles, *Crassispora* has two distinct broad zones of low abundance, one in the top and the other in the lower middle portion of the seam. These zones are interpreted as times in the history of the swamp when *Sigillaria* was present locally. In coal-ball profile VS 3-5, the pattern is somewhat similar, with *Sigillaria* being found in the very top increment of the seam and in the middle of the seam (three coal-ball increments). *Sigillaria* appears to vary more in abundance in the coal-ball samples (reaching
almost 50% in one sample), while it never exceeds 5% in the coal miospore profiles. *Sigillaria* also shows variation between sites in coal-ball sampling. A comparison with samples collected at the same level from other sites shows that it is not present at all in VS 6 and only at a lower level in VS 4. Differences like this would be expected if the vegetation were somewhat patchy. Then coal balls would represent a more local sampling of the vegetation at the site, and the miospores, while still mainly from the immediate vegetation, would represent a somewhat larger sampling area, with some spores originating from more distant vegetation. These differences may also explain why more coal-ball taxa are restricted to certain levels and are found in higher percentages than is true of their miospores.

Some Related And Future Work

The palynological and coal-ball vegetational analysis work done by others in the Illinois Basin coals (see Introduction) has provided a basis for understanding these coal swamps and served as a necessary reference for this thesis. Both coal-ball and palynological analysis has continued since this work was started on these Middle Pennsylvanian coal swamps. Most of the coal-ball analysis has been done by Tom Phillips and one of his former students Bill DiMichele (See: Phillips, T.L. and Peppers, R.A., 1984; Phillips, T.L. and DiMichele, W.A., 1992; Bateman, R. M., DiMichele, W. A., and Willard, D. A. 1992; DiMichele, W.A., and Phillips, T.L., 1994). The palynological work on the Springfield Coal (Chapter 2) has been greatly expanded by Debra Willard, with an extensive series of palynological profiles across this coal (1993). She also did the palynology (Willard *et al.*, 1995) for one of the best studies on the
paleoenvironment of the facies of the Leslie Cemetery Channel. The environmental interpretation is strengthened in her study by tying the palynology of these facies to a number of other fossils (compressions, coal-balls, and conodonts).

Several other projects related to this thesis have been developed by the author. Samples have been collected from the Lexington Coal in north central Missouri (ten miles east of Unionville). This coal of the Western Interior Basin is correlated with the Herrin in the Illinois Basin. Analysis of these samples will allow a comparison of the Herrin Coal profiles to a profile from a neighboring basin that has more of a marine influence (Wanless et al., 1969; Raymond and Phillips, 1983).

Another possible project would continue the analysis of miospore variation in a local area reported for the Old Ben Mine (Chapter 4), with more extensive sampling at specific levels of the seam from a third coal mine. Samples were collected in this mine (Freeman Co’s Crown No. 2 Mine) at and around both the “blue band” and at a higher clastic band, both of which could serve as time markers in the history of the seam. Since these clastic bands are persistent in the Herrin, these samples should show the amount of palynological variation at one time both in the local area of each mine and between this and the Old Ben Mine, separated by 160 km.

A third project (at the initial manuscript stage) quantifies more directly the relationship between spores and coal-ball vegetation from the same samples using R-value comparisons (Davis, 1963). R-values are a simple ratio of the percent of pollen (in this case miospores from coal balls) to the percentage of its source plant enabling one to quantify the relationship of individual miospore taxa within a flora to the abundance of their source plant. In this study
suites of R-values are displayed with geometric regression lines (Bradshaw and Webb, 1985; Delcourt, Delcourt, and Davidson, 1983; Short, Andrews and Webber 1986) for a better approximation of the real ratios, since simple R-values are percentages that can vary with changes in the amount of other taxa. In this study, miospores were extracted from one coal ball of each of five zones from a coal-ball site (V.S. 5 at the Sahara locality) and compared to the vegetation averages for the plants of that zone. One interesting and unanticipated result of this analysis is that the same taxon’s R-values were much more variable when calculated from the individual zones. However, the R-values calculated on seam averages tended to be very similar (Table 5.4).

A satisfying outcome of this thesis was seeing how once they were described, the palynological patterns could be combined with other information to address some basic questions about vegetational patterns and ecological dynamics of the coal swamp. Comparison of palynology and coal-ball studies provided insight into the patterns of vegetation not apparent from the palynology alone. Use of a different swamp model, a tropical instead of temperate deltaic model, forced the author to consider a different way of looking at the swamp and to speculate whether some of the peat may have been domed peat. When combined with other information, the palynology described in this thesis adds to the wealth of other information and helps in understanding the ecology of these large and important coal swamps.
Figure 5.1  Location of the two collecting localities in the Herrin, Old Ben 24 and Sahara 6 Coal Mines, and relationship to the Walshville channel.
Figure 5.2  Map showing sampling sites in the Springfield (NO. 5) Coal and known contemporaneous channels  (Modified after Treworgy & Bargh (1982) and Eggert (1982)). Insert from the Southeastern area shows the split coal used to map one of these channels, the Leslie Cemetery Channel. (Modified from Eggert 1982).
Figure 5.3   Patterns of abundance of *Lycospora granulata* in the coal above the “Blue Band” at Site 1 and 2 at Old Ben. The same data is plotted below as ratios comparing the amount of *L. granulata* in corresponding subdivisions (zones) of the two profiles.
Patterns of Lycospora granulata at two sites at Old Ben
**Ratio of Lycospora Spores**
From Sites 1 and 2 at Old Ben

![Graph showing the ratio of Lycospora Spores from Sites 1 and 2 at Old Ben. The x-axis represents Site 1 (AYN), and the y-axis represents Site 2 (AYD). The average of Zones (1=top) is indicated on the graph.](image-url)
Figure 5.4 Patterns of abundance of the tree-fern miospores in the coal above the “Blue Band” at Site 1 and 2 at Old Ben. The same data is plotted below as ratios comparing the amount of the tree-fern miospores in corresponding subdivisions (zones) of the two profiles.
Comparison of all Tree Ferns
At two sites at Old Ben

Zone Average of Top 7 Zones (1=top)
Site 1 Site 2
Comparison of all Tree Ferns
At two sites at Old Ben
Ratio of all Tree-Fern Spores
From Sites 1 and 2 at Old Ben
Figure 5.5    Patterns of abundance of the tree-fern miospore *Thymospora pseudothiessenii* in the coal above the “Blue Band” at Site 1 and 2 at Old Ben. The same data is plotted below as ratios comparing the amount of the tree-fern miospore *Thymospora pseudothiessenii* in corresponding subdivisions (zones) of the two profiles.
Patterns of Thymospora
At two sites at Old Ben

Ratio of Thymospora Spores
From Sites 1 and 2 at Old Ben
Figure 5.6  Patterns of abundance of the large species of *Laevigatosporites* in the coal above the “Blue Band” at Site 1 and 2 at Old Ben. The same data is plotted below as ratios comparing the amount of the large species of *Laevigatosporites* in corresponding subdivisions (zones) of the two profiles.
Patterns of Laevigatosporites spp.

At two sites at Old Ben

Site 1 Site 2

Patterns of Laevigatosporites spp.

At two sites at Old Ben

Ratio of Laevigatosporites

From Sites 1 and 2 at Old Ben

Site 2 (AYD)

Site 1 (AYN)

Average of Zones (1=top)
Table 5.1  Comparison of percent distribution of major miospores in Herrin Coal on a whole seam basis.

<table>
<thead>
<tr>
<th>TAXA</th>
<th>Sahara Sites</th>
<th>Regional Average (Peppers, 1970)</th>
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<tbody>
<tr>
<td></td>
<td>Peat (ACO)</td>
<td>Coal (ACA)</td>
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<tr>
<td><em>Lycospora granulata</em></td>
<td>46.0</td>
<td>49.5</td>
</tr>
<tr>
<td><em>Lycospora</em> spp.</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>LYCOPODS (SUBTOTAL)</td>
<td>53.5%</td>
<td>53.5%</td>
</tr>
<tr>
<td><em>Thymospora</em></td>
<td>3.0</td>
<td>13.5</td>
</tr>
<tr>
<td><em>Laevigatosporites minutus</em></td>
<td>10.5</td>
<td>3.0</td>
</tr>
<tr>
<td><em>Laevigatosporites globosus</em></td>
<td>9.5</td>
<td>15.5</td>
</tr>
<tr>
<td><em>Punctatisporites</em></td>
<td>12.0</td>
<td>5.0</td>
</tr>
<tr>
<td><em>Cyclogranisporites</em></td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>FERNS (SUBTOTAL)</td>
<td>36.0%</td>
<td>38.5%</td>
</tr>
<tr>
<td><em>Calamospora</em></td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td><em>Laevigatosporites</em> (large spp.)</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>SPHENOPSID (SUBTOTAL)</td>
<td>4.5%</td>
<td>5.0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>94%</td>
<td>97%</td>
</tr>
</tbody>
</table>
TABLE 5.2  Pairwise similarity of palynological samples from coal and coal balls from Sahara on whole seam averages.

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Coal Ball</th>
<th>Coal</th>
<th>Coal</th>
<th>Coal (regional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>ACO</td>
<td>ACA</td>
<td>ACN</td>
<td>Peppers data*</td>
</tr>
<tr>
<td>Coal Ball</td>
<td>1.00</td>
<td>0.85</td>
<td>0.81</td>
<td>0.78</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td>1.00</td>
<td>0.84</td>
<td>0.81</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Coal (regional)</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Peppers, 1970.
Table 5.3 Comparison of spore and vegetation percentages.

<table>
<thead>
<tr>
<th></th>
<th>OLD BEN NO. 24 SITES</th>
<th>SAHARA SITES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Western</td>
<td>Eastern</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#14/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#10/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACA/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS 3 &amp; 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lycospora granulata**
- Western: 51.3
- Eastern: 50.5
- Sahara: 41.9
- Whole Seam Averages: 55.5

**Lepidophloios halli**
- Western: 57.45
- Eastern: 57.45
- Sahara: 29.6
- Whole Seam Averages: 49.2

**Tree fern spores**
- Whole Seam Averages: 18.9

**Psaronius**
- Whole Seam Averages: 11.4

**Small Ferns spores**
- Whole Seam Averages: 1.8

**Small Ferns veg.**
- Whole Seam Averages: .4

**Sphenopsids spores**
- Whole Seam Averages: 4.2

**Sphenopsids veg.**
- Whole Seam Averages: 2.63

**Vesicaspora**

**Florinites**
- Whole Seam Averages: .57

**Cordaites**
- Whole Seam Averages: .1
Table 5.4   Comparison of the similarity of R-values (peat/vegetation ratios) of individual-coal ball zones from Sahara vs 5.
COMPARISON OF THE SIMILARITY OF R-VALUES (PEAT/VEGETATION RATIOS) OF INDIVIDUAL-COAL BALL ZONES FROM SAHARA VS 5. (Similarity based on R-values of Lepidophloios, tree ferns, and sphenopsids at each site).

<table>
<thead>
<tr>
<th>COAL BALL ZONES OF VS 5</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Average (2-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMILARITY TO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEAM AVERAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ratios of ACA/VS 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.547 (.892)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.978 (.927)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.721 (.407)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>.957 (.781)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.941 (.794)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDIVIDUAL ZONE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.708</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>.342</td>
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<tr>
<td>.373</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.708**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Similarity within parentheses also includes R-values of small ferns and Callistophyton.
** Similarities also include Callistophyton.