1986

Biostratigraphy and Palaeoecology of Carboniferous Ostracodes in the Black Warrior Basin

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Open-File Report 86-2F

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The Mississippi Mineral Resources Institute
University, Mississippi 38677

BIDSTRATIGRAPHY AND PALAEOECOLOGY OF
CARBONIFEROUS DSTRACODES IN THE
BLACK WARRIOR BASIN

FINAL REPORT

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Insti tuti on : Mississippi State University

MMRI Grant : 86—2F

U.S. Bureau of Mines: Grant #61154128

Abstract

New research involving Carboniferous palaeontology of the Black Warrior Basin has been focussed on the Bangor Limestone and the Pottsville Formation.

Ostracode studies in the lower Bangor Limestone will serve as a basis for continued study in the region. Ostracode samples collected from the lower Bangor in Franklin and Colbert Counties, northwest Alabama have yielded a very abundant, high diversity, well preserved. Mid—Continent-type fauna. Preliminary results show that the fauna can be resolved into four major shelf environment assemblages: i) Bairdiacean dominated Assemblage

ii) Bairdiacean—Pplytylites Assemblage

iii) Mixed Ba irdi a—Kloed en ellac ean Assembi age

iv) Kl oedenel 1 acean Assemblage

Macroinvertebrate studies in the Upper Pottsville Formation were conducted to explore the vertical extent and distribution of marine fossil horizons in the Inter—Coal Group intervals in Tuscaloosa, Walker and Cullman counties, northwest Alabama. Three, intergradational assemblages have been defined, which demonstrate that fossil occurrences are much more extensive than previously recorded in the region. The assemblages include a brackish water Orbi culoidea Assemblage, a restricted environment

Chonetid Assemblage and a more diverse, open marine Productid Assemblage. Faunal components indicate that salinity was a major control upon occurrence, and that substrate type only acted as a secondary control.

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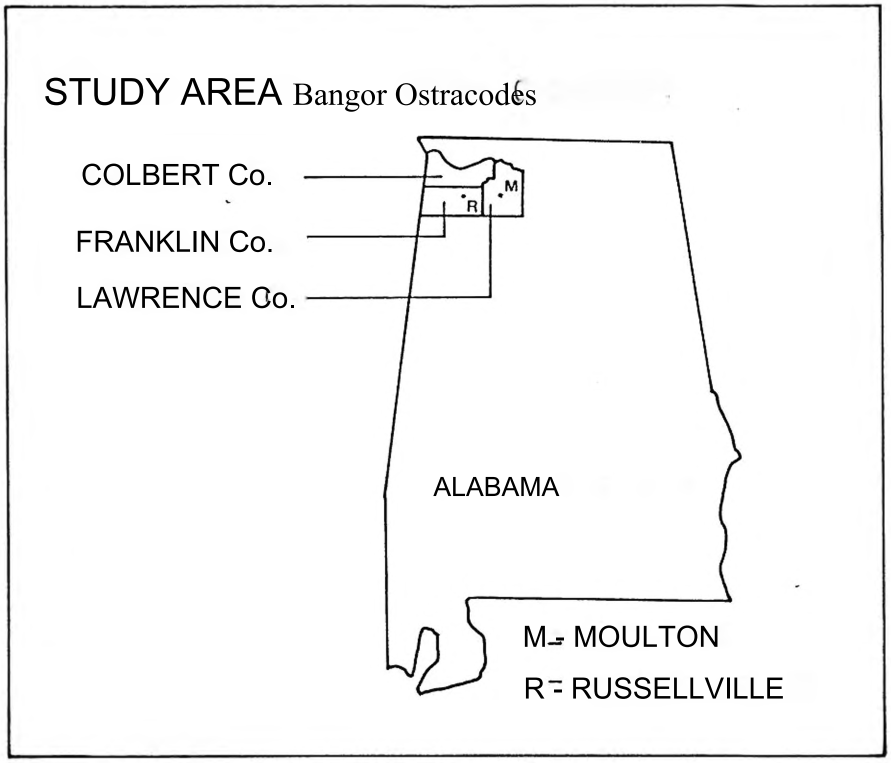
INTRODUCTION

I. General Remarks

The study of Carboniferous ostracodes in the Black Warrior Basin of Mississippi and Alabama is a new field of investigation

The primary purpose of Project 86-2F was to describe ostracodes from both the outcrop and subsurface in northern Alabama, and to evaluate their usefulness as a biostratigraphic and/or pal aeoenvi ronment al tool for basin analysis. The project was the first of a developing research program which has three major objectives: i) to extend expertise in ostracode taxonomy, pal aeoecol ogy and bi ostrati graphy, ii) to use these data in palaeoenvironmental and stratigraphic interpretation of the Black Warrior Basin, and iii) to apply such research in the exploration for, and exploitation of hydrocarbon reserves in the basi n.

The initial proposal was too broadly based and intial field work in northern Alabama provided such encouraging results that it was necessary to refocus the project significantly. Initial data collections suggested that the most useful areas of investigation included the analysis of ostracodes from the lower Bangor and the general macro!nvertebrate palaeontology of the Upper Pottsville. Since each part of this project was



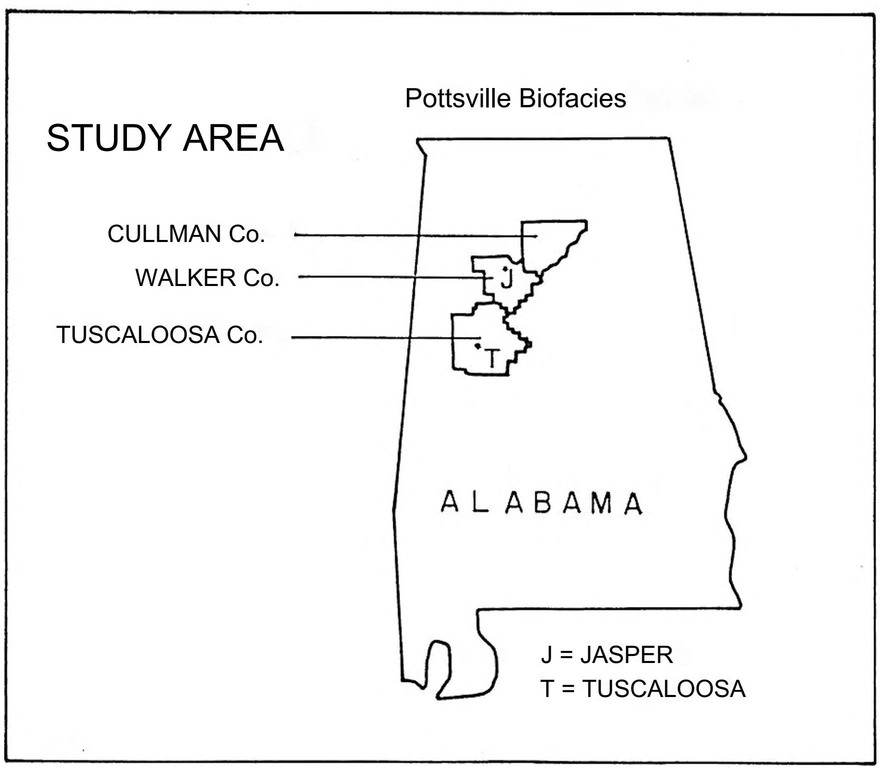


Figure 1: Location of Study Areas

essentially a discrete entity the results are given in two secti ons.

II. Location of Study Area

The study was conducted entirely within the outcrop belt of the Black Warrior Basin in northern Alabama. There are two main areas of research (Fig. 1). The study of ostracodes from the Bangor Limestone was conducted in Colbert and Franklin counties; while the study of inter-coal group fossil sequences in the Pottsville was conducted in Tuscaloosa, Walker and Cullman Counties.

Major cities in the region include Tuscumbia and Muscle Schoals, Red Bay and Russellville in Colbert and Franklin counties respectively- In the southern area Tuscaloosa, Jasper and Cullman act as the major population centres.

The field areas are traversed by a series of U.S. Interstate and Alabama State Highways as well as a network of lesser county and secondary roads.

III. Physiography

The study areas were contained within two physiographic regions of the Black Warrior Basin (Fig- 2). The Highland Rim forms the northern physiographic area, and the Cumberland Plateau forms the southern physiographic area. The western edge of the study areas is defined by the onlapping Upper Cretaceous sediments of the Fall Line Hills District of the Eastern Gulf Coastal Plain.

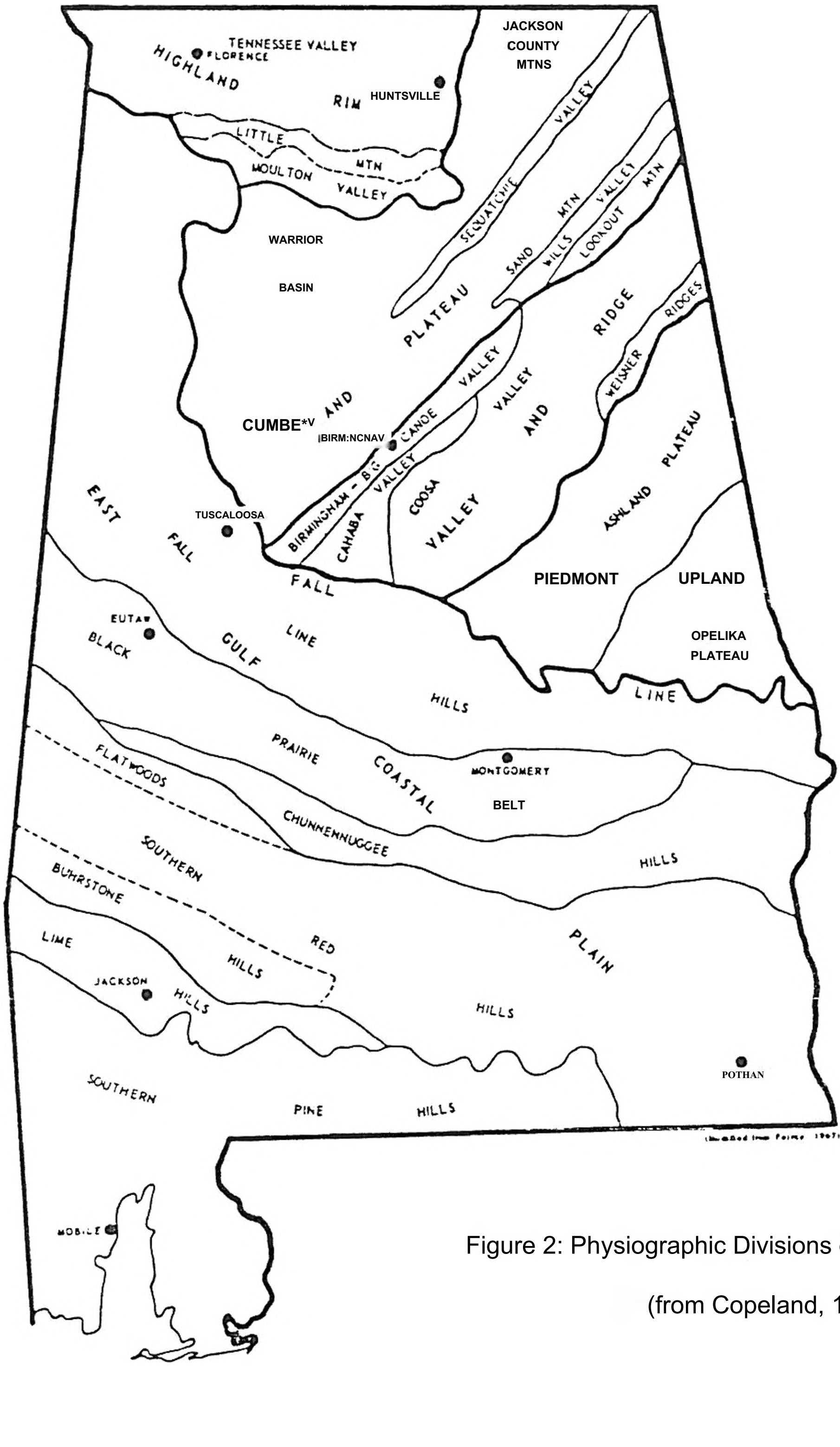


Figure 2: Physiographic Divisions of Alabama

(from Copeland, 1968.)

The Highland Rim is subdivided in Alabama according to local relief and lithology. In general, the Highland Rim is a rolling upland of moderate relief underlain by Mississippian carbonate and clastic deposits- To the south of the Highland Rim, the dissected region of the Cumberland Plateau is developed on resistant Prennsylvani an sandstones. The northern border of the Cumberland Plateau is marked by an escarpment, the crest of which is about 100-170m above the Moulton Valley District of the Highland Rim. The escarpment forms the divide between the Tennessee River system to the north and the Warrior River system to the south.

More complete details of the physiography are given in Johnson (1930); Fenneman (1938)5 Copeland (1968); and Sapp and Emplaincourt (1975).

PREVIOUS INVESTI8ATIDNS

I. The Bi ack Warrior Basin

The Black Warrior Basin (Fig. 3) is a triangular area of about 86,900 sq. kms. (Mellen, 1947). The northern boundary is marked by the Ozark and Nashville domai structures. The southeastern and southwestern boundaries are structurally defined by the Appalachian and Ouachita orogenic fronts respectively. Any studies involving the evolution of the Black Warrior Basin must therefore be intimately concerned with the evolution of the adjacent mobile belts. The basin was not a discrete entity prior

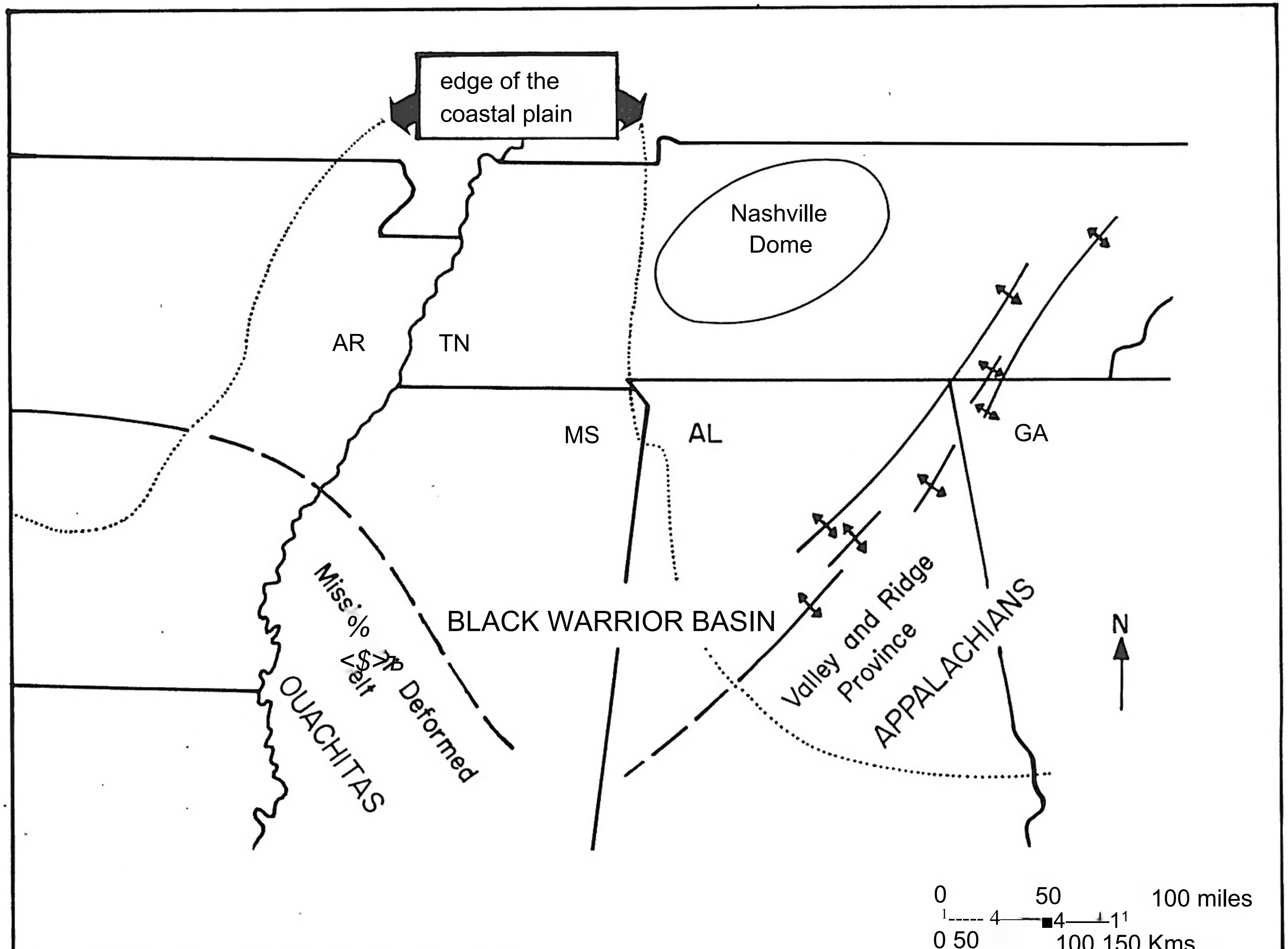


Figure 3 : The Black Warrior Basin

to the middle Mississippian, since isopachs for earlier strata bear no relation to the basin and tend to parallel the adjacent mobile belts (Kidd, 1975). During the Mi ssissippi an and Pennsylvanian, the Black Warrior Basin was a mixed carbonate-clastic platform and foreland basin which developed on the Alabama continental promontory (Thomas, 1977; Thomas and Womack, 1983), between the adjacent Ouachita and Appalachian mobile belts.

Potential source areas for basin-filling clastics are a matter of debate and suggested source areas include the northern craton as well as both the mobile belts (Swann, 1964; Hobday, 1974; Thomas, 1974; Graham et.al., 1976; Cleaves and Broussard, 1980; Horsey, 1981; Mack et.al., 1981, 1983).

A plate tectonic origin for mobile belts is related to island arc and/or continental margin convergences (Wickam, et. al., 1976; Thomas and Neathery, 1982; Mack, et. al-, 1983), involving the southeastern margin of North America and the northwestern margin of Gondwanaland.

II» Stratigraph!c Nomenclature

The Carboniferous stratigraphy of the Black Warrior Basin (Fig. 4) can be subdivided into three major intervals:

i) early Mississippian cherty carbonates,

ii) late Mississippian platformai carbonates and progradati onal clastic wedges,

and iii) Pennsylvanian progradational clastic wedge.

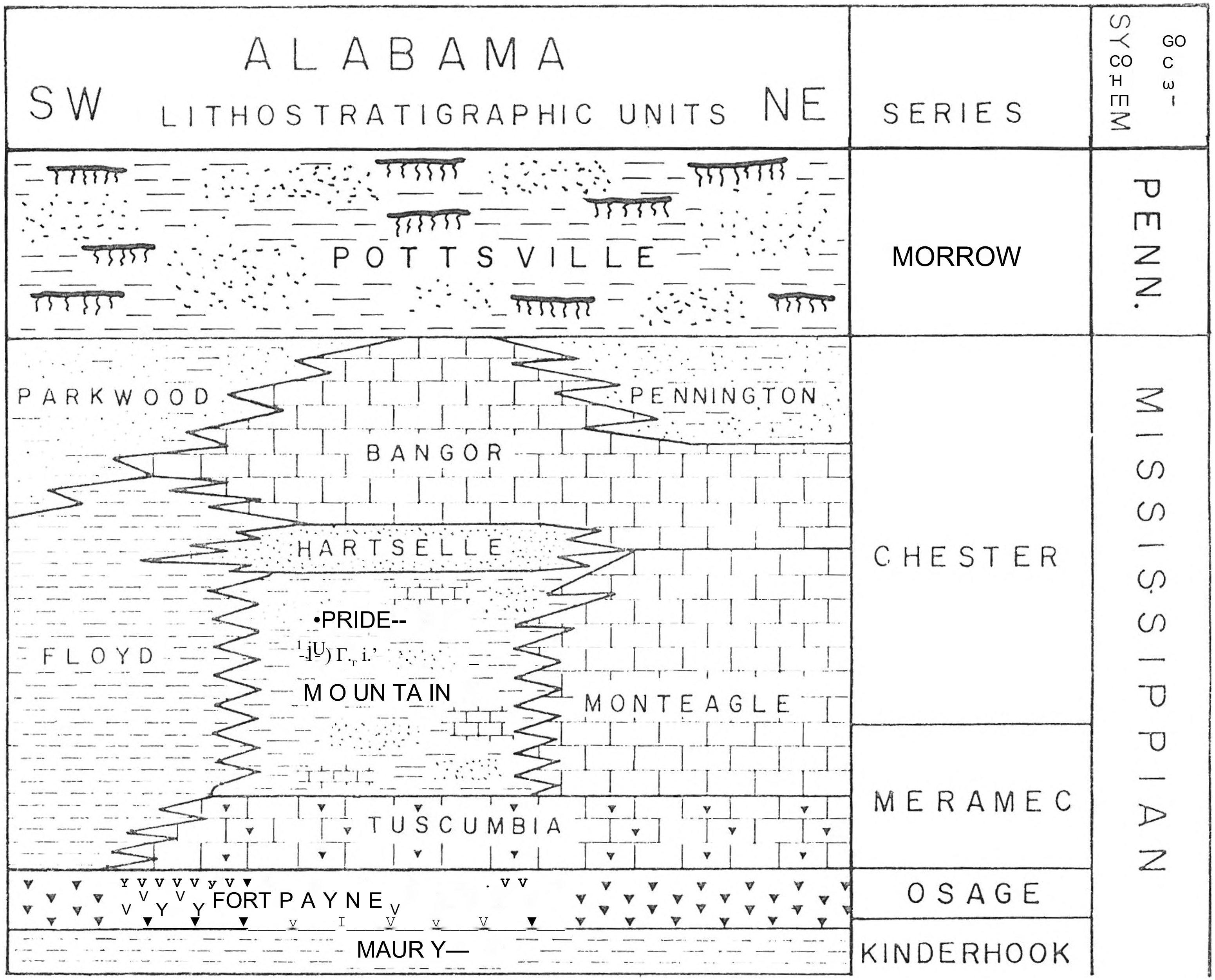


Figure 4 : Carboniferous Stratigraphy of the Black Warrior Basin

Estimates for thicknesses of the entire stratigraphic package range up to more than 3,000 m (Thomas, 1972; Ferm and Weisenfluh, 1979; Musgrove, 1982).

Early Mississippian cherts and cherty limestones in the Black Warrior Basin include about 110 m of the Fort Payne and Tuscumbia which mark the base of the Carboniferous System in northern Alabama- Megafaunal correlations of the Fort Payne (Butts, 1926; Drahovzal, 1967) indicate a time equivalence to Osage units in the Mississippi Valley. The bioclastic and micritic limestones of the Tuscumbia represent the initiation of a major Mississippian carbonate bank in northern Alabama.

The late Mississippian platformai carbonate sequence which overlies the Tuscumbia is associated with three progradational clastic wedges. The carbonate bank developed primarily in northeast Alabama on the "East Warrior Platform" (Thomas, 1972). The carbonate sequence can be subdivided into the lower massively bedded, 65 m thick Monteagle Limestone and the upper, more extensive, 150 m thick Bangor Limestone. Both units are composed of oolitic and bioclastic limestones and both thin and interfinger with clastic wedges to the west and southwest. The Bangor also thins to the northeast and grades into a third clastic wedge.

The provenance of Mississippian clastic wedges in the Black Warrior Basin is a matter of continuing controversy. There are three major clastic wedges which include:

i) the Floyd Shale, Pride Mountain Formation and Hartselle Sandstone

ii) the Parkwood Formation

and iii) the Pennington Formation

The Floyd—Pride Mountain-Hartselle package is a southwesteri y thickening wedge that extends northeastward over the western Black Warrior Basin- The Pride Mountain is a mixed carbonate— clastic unit (Welch, 1958; Thomas, 1974). It is the most extensive part of the wedge and intertongues with the Monteagle Limestone. The Floyd—Pride Mountain-Hartselle sequence is the first of the basin-filling clastic wedges and is thought to be derived from a southwestern source (Thomas, 1972). Overlying the Pride Mountain is the Hartselle sandstone, which is suggested to be a barrier island and shelf bar deposit (Thomas and Mack, 1982; Mack et.al., 1981).

Overlying the Floyd Shale are the mixed shales and sandstones of the Parkwood Formation which thin eastward onto the East Warrior Platform. Mack et.al., (1981, 1983), suggest that the Parkwood represents a northeastward prograding delta complex.

By contrast Cleaves and Broussard (1980) and Cleaves (1983) suggest that the Floyd and Parkwood clastic wedges were derived from an interior cratonic source to the northwest. This view is supported by a study which suggests that the subsurface Carter

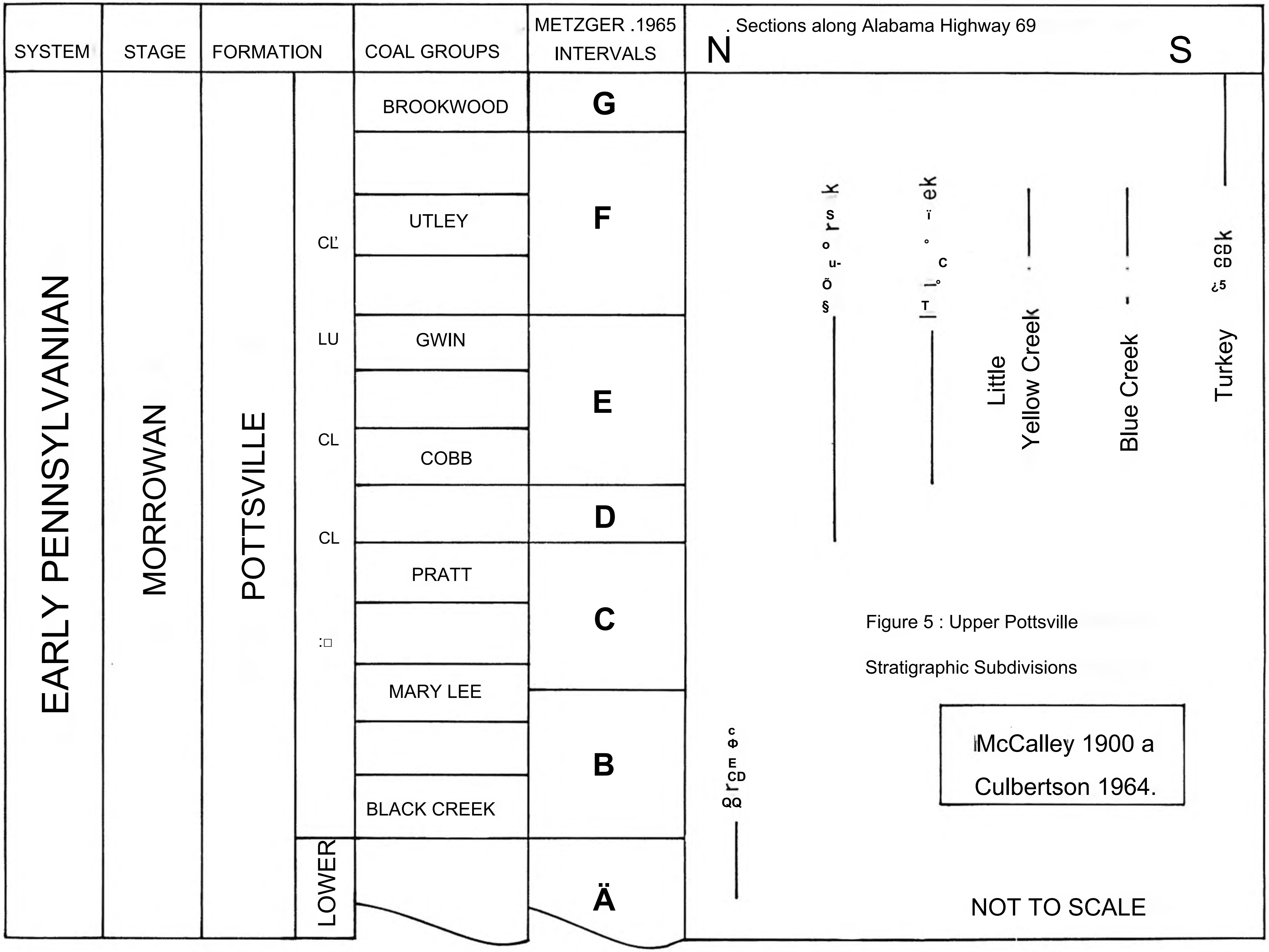


Figure 5 : Upper Pottsville Stratigraphic Subdivisions

Sand (Parkwood) was part of a southeastward prograding delta system (Bearden and Mancini, 1935)»

The interbedded sands and shales of the Pennington Formation represent the last Mississippian clastic progradation into the Black Warrior Basin. The Pennington is thickest (about 130 m) in northeast Alabama and thins to the southwest. It is thought to be derived from an Appalachian source (Thomas, 1974; Cleaves and Broussard, 1980).

The Pennsylvanian was marked by the development of the major progradational wedge of the Pottsville Formation. The lower Pottsville is composed mostly of massive sandstones and interbedded shales, but is generally devoid of coals, (McCalley, 1886; Butts, 1910; Metzger, 1965). The upper Pottsville (Fig. 5), is characterized by thick, fine clastic intervals, local sandstones and several distinct coal horizons. The latter have served as a basis stratigraphic subdivision (McCalley, 1900; Culbertson, 1964; Metzger, 1965).

Depositional environments for the Pottsville Formation have been discussed by a variety of authors. Metzger (1965) suggests that sandstones of the Pottsville were deposited in fluvial or deltaic environments and that marine units in the sequence indicated periods of inundation. Most of the marine zones in intervals A, C, D & E (Fig. 5) are relatively thin, but lateral persistence was noted for some marine units in intervals C and D-Ferm and Ehrlich (1967) proposed a complex series of depositional environments including deltaic, lagoonal, barrier island and open bay settings -for the lower Pottsville, and Hobday (1974) supported a barri er—related origin for sandstones of the lower Pottsville. Depositional settings for the entire Pottsville (Horsey, 1981), include barrier bar, lagoon and tidal flat environments for the lower Pottsville; and 1 ower delta plains, interdistributary bays and barrier bars for the upper Pottsville.

Although there are proponents of Ouachita (Cleaves and Broussard, 1980) vs. Appalachian (Metzger, 1965; Braham, et. al-, 1976) source areas, it is likely that two source areas provided material for the Pottsville as two wedges coalesced over the Black Warrior Basin. A north or northeastward prograding wedge from an Ouachita source merged with an Appalachian-derived southwestward prograding wedge (Hobday, 1974; Thomas, 1974; Smith, 1979; Horsey, 1981; Mack et.al., 1981, 1983).

II. Ostracodes

The foundation studies for Carboniferous ostracodes in North America were laid by Ulrich and Bassler (Ulrich, 1891; Ulrich and Bassler, 1906, 1908). During the late 1920's to 1940's, mid-continental U.S.A. became the focus of ostracode research. During this time two of the most important workers included

Coryell and his students (Coryell and students, 1928, 1931, 1932, 1933, 1938, 1939, 1942) and Croneis and his students (Croneis and students, 1938, 1939). Perhaps the most significant solitary worker was Chalmers B. Cooper who published with ths Illinois Survey (Cooper, 1941, 1946). Other important workers included Bradfield (1935); Delo (1930,1931); Geis (1932); Harlton (1927, 1928, 1929a, b, 1933); Kellett (1933, 1934, 1935) and Morey (1935a, b, 1936). Since most of these works represented new data featuring many new species, taxonomic synonymy has become a problem in recent years. It is interesting to note that the Black Warrior Basin was never investigated for ostracodes, thus leaving a potentially rewarding research area untouched. Only three works mention ostracodes from the Black Warrior Basin (McG1 ammery, 1955; Ehrlich, 1964; Mandelbaum, 1971). McGlammery (1955) was a subsurface report which only identified the presence of ostracodes in core samples- Ehrlich (1964) described a small fauna from a single sample in the Pennington and Mandelbaum (1971) is an unpublished Masters thesis on both the Pride Mountain and Monteagle. An abstract (Devery and Dewey, 1986), is the first in a series of publications that will evolve from a detailed analysis of Carboniferous ostracodes in the Black Warrior Basin. Using scanning Electron Microscopic techniques, Devery and Dewey (1986) have identified a highly abundant and diverse ostracode fauna from the lower Bangor of northwest Alabama. The fauna is important for delineating ostracode assemblages and for refining pal aecenvi ronmertal i nterpretati ons. Continued study through the Carboni!erous stratigraphic package in the Black Warrior Basin, will demonstrate the extent to which the -fauna may be used for bi ostratigraphic study.

III. Palaeontology

A review of macro- and non-ostracode micro-palaeontological research in the Black Warrior, reveals that very few detailed studies have been published.

Most of the original palaeontological foundations were laid by Butts (1926), who not only described an extensive fauna from the basin, but also correlated the fauna with Mississippi Valley sections. Further correlative work was added by Drahovzal (1967). Major contributions to Mississippian bryozoan and crinoid palaeobiology were completed by McKinney (1972) and Burdick and Strimple (1982) respect i vel y. Whisonant (1970) and Henry et.al. (1985), and Waters (1978) described macro-invertebrate faunas from the Parkwood and Bangor Formations respecti vely. Pottsville faunas have however, received more attention (Metzger, 1965; McKee, 1975; Gibson, 1983, 1985).

In contrast little micropalaeontologi cal work has been completed and even less has been published. The arenaceous and fusulinine forams have been studied by Conkin and Ciesielski (1973) and Rich (1980). Conodonts have been described from the Tuscumbia by Ruppel (1971) and from the Bangor by Johnson (1974).

There have been no mi crcpai aeontol ogi cal studies involving Pottsville sediments.

METHODOLOGY

I. Field Methods

As a foundation for further work, -field studies in the Bangor Limestone were localised to Colbert and Franklin counties, where the upper Mississippian carbonate platform and clastic wedges intertongue. It was anticipated that work in this region, where limestones of the Bangor inter-finger with -fine clastics of the Floyd (Thomas 1972) would yield an extensive ostracode fauna that could act as a basis for continued work.

A single highway traverse was chosen for the Pottsville study. Alabama State Highway 69 from Tuscaloosa to Cullman was selected because it affords extensive outcrops of Pottsville sediments and approximates to a dip section through the entire Pottsville (Fig. 6).

In both aspects of the work, the established literature was used as an initial data base for outcrop location. For reconnaissance fieldwork, outcrops were investigated from (Metzger, 1965; Thomas, 1972; McKee, 1975; Waters, 1978; Burdick and Strimple, 1982)-

A series of 7-5 minute USGS and TVA topographic quadrangle maps were used as base maps- After reconnaissance work, exact field locations were chosen that reflected the aims of the research. Detailed measured sections were constructed using standard procedures with Brunton, hand level and staff.

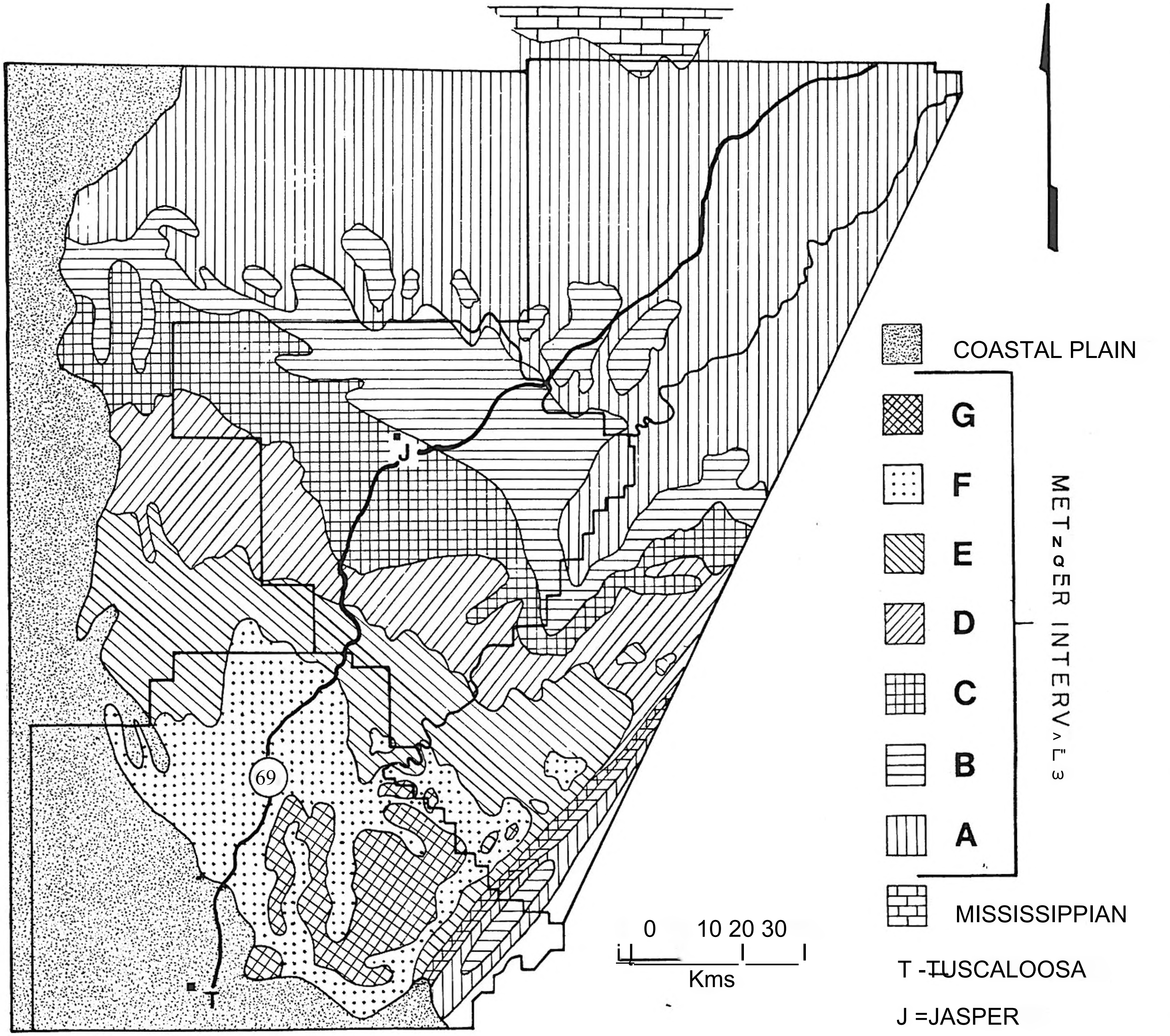


Figure 6: Distribution of Pottsville Outcrop Belts and Alabama Highway'69. (adapted from Metzger 1965)

The sampling net for the ostracode study was determined by lithology, macro fossil content and vertical thickness of the unit. It was important to prevent time-averaging and multi-environment sampling; therefore, samples were collected from as narrow vertical thickness as possible.

Outcrops were photographed using 400 ASA black and white print film to produce composite mosaics of the entire outcrop, and also 64 ASA slide film for individual parts and details of the outcrops.

II- Laboratory Methods

Micropalaeontological samples weighing about 2kg were processed according to the following methods

i) Maceration to 1 cm- sized fragments and oven drying at 60° c.

ii) Simmering in a solution of Calgon and aliquots of H_20_s to promote di saggregati an-

ii i) Wet sieving at 2mm, 1mm, 0.5mm, 0.25mm, 0.125mm and 0.063mm-

iv) Oven drying and bottling.

Initial sample picking and ostracode identi f ication used a Bausch and Lomb research binocular microscope. In most samples the bulk of the ostracode fauna was found in the 0.5mm and 0.25mm size fractions. Individual ostracodes were cleaned in an ultrasoni cator.

Taxonomic details were studied using an Hitachi HHS-ZR scanning electron microscope. Dstracodes chosen for their preservational quality, were mounted on Aluminum stubs with double stick tape and were coated in a Gold-Platinum alloy prior to scanning. Individual specimens were then photographed using a polaroid attachment and Polaroid Type 55 land film.

Macrof aunal samples were prepared by splitting rock slabs along bedding planes and cleaning specimens with dentistry utensils. Individual specimens were often ultrasonicated to remove debris. Macrofossi is were photographed using a 4—lamp light table, Praktica TL 1000 camera with 55mm lens and optional bellows attachment. Specimens were photographed using 400 ASA Tri-X Pan, and 200 ASA Ektachrome film.

RESULTS

Bangor Dstracodes

a) Measured Sections and Lithofacies

The description of ostracode biofacies from the Mississippian Bangor Limestone of northwest Alabama was restricted initially to six measured sections in Franklin and Colbert counties (Fig. 7)- The sections were restricted to the lower units of the Bangor where it intertongues with the Floyd shale (Fig- 4). The intention was to obtain samples from mixed carbonate—cl astic settings which would provide a large enough fauna to act as a basis for continued study-

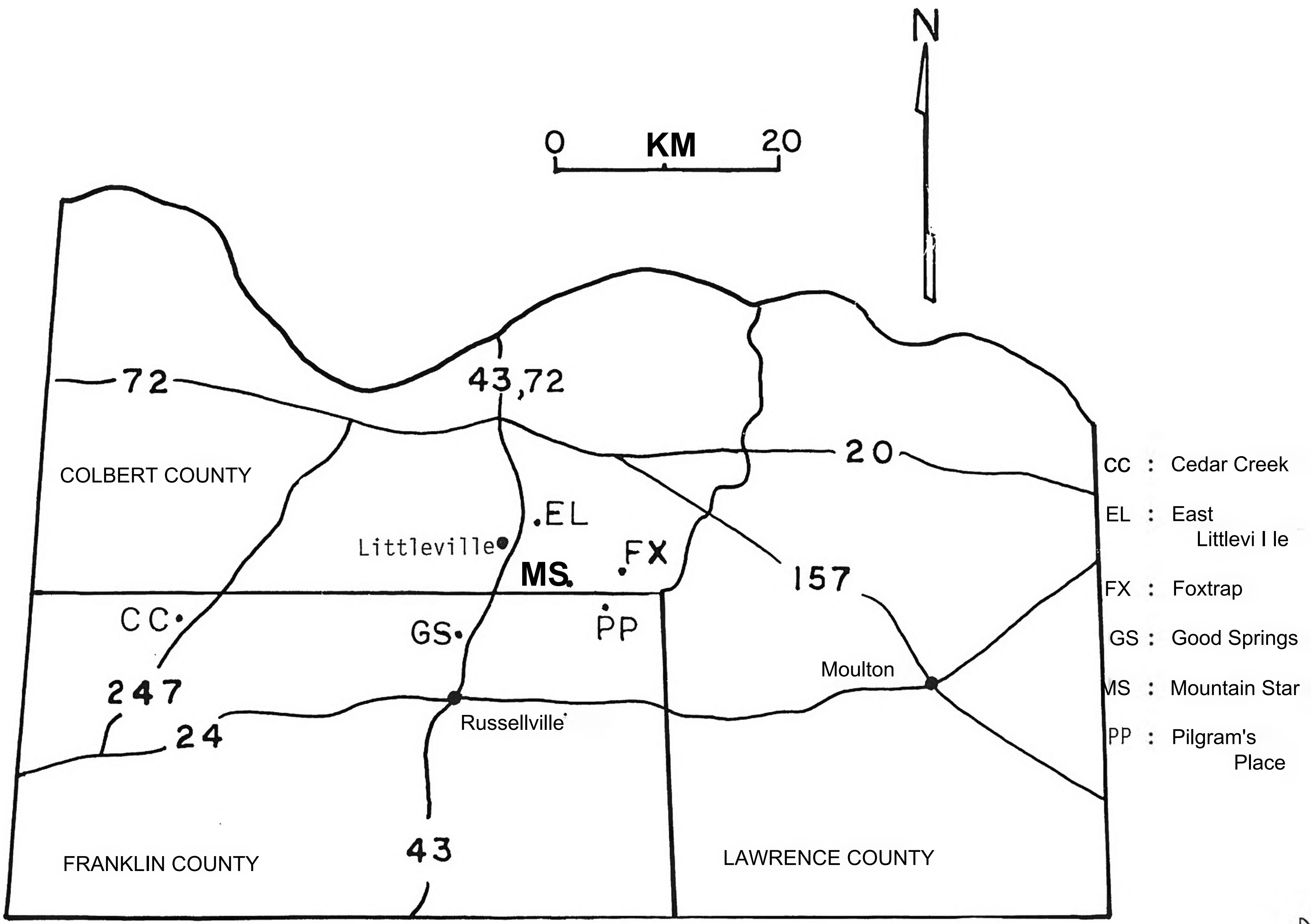


Figure 7 : Location of Bangor Outcrops used for Biofacies Analysis.

The sections were correlated by field techniques and a computer best fit plane program, to the top of the Hartselle Sandstone. in total, some 70 m of sections were measured and 34 samples were collected for ostracodes. Most of the sections are easily accessible road cuts along county roads and their detailed examination and ostracode palaeoecology form part of an ongoing MS thesis at M.S.U.

From East to West the measured sections were as follows:

i) Foxtrap (Fig. S)
NW 1/4 SE 1/4, Sec 31, T5S, R1OW. 3.5 miles E. of Littleville.

ii) Pii gram's Place (Fig. 9)
W 1/2 NW 1/4, Sec 7, T6S, R10W. Exposure on private farm on county highway 56 about 1.5 miles E. of Mountain Star.

iii) Mountain Star (Fig. 10)
E 1/2 SE 1/2, Sec 35, T5S, R11W. Roadcut on W. side of county highway 55, 0.5 mile N. of Franklin Co. line.

iv) East Littleville (Fig. 11)
NW 1/4 SW 1/4, Sec 26, T5S, R11W. Roadcut on N. side of county highway 77, 0.5 mile E. of Li ttlevi lie.

v) Good Spring (Fig. 12)
NE 1/4 SW 1/4, Sec 9, T6S, R11W. Roadcut on W. side of U.S. highway 43 about 3.5 miles N- of Russel ville.

iv) Cedar Creek (Fig. 13)
SW 1/4 NE 1/4, Sec 11, T6S, R14W. Roadcut on NW side of state highway 247 about 0.5 mile N. of Cedar Creek.

The sections can subdivided into three major lithofacies which can be summarized as follows:

i) Mudstone Lithofacies

This lithofacies is composed of fissile, buff weathering, pale grey, calcareous shales and siltstones. The

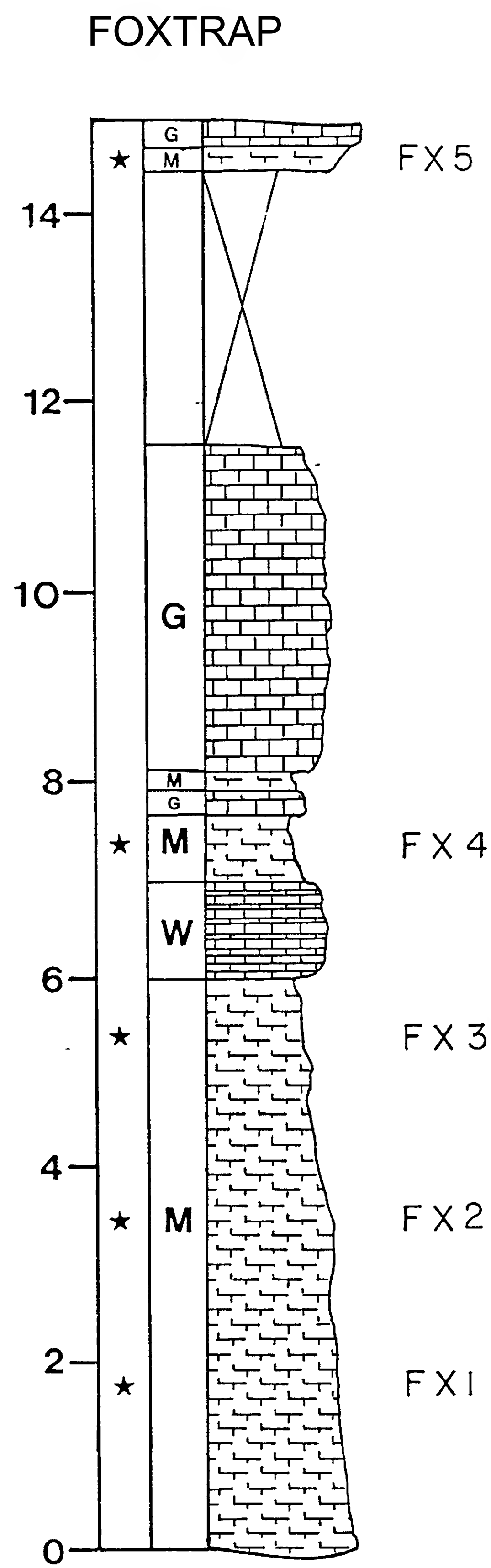


Figure 8 : Foxtrap Section.

PILGRAM'S PLACE

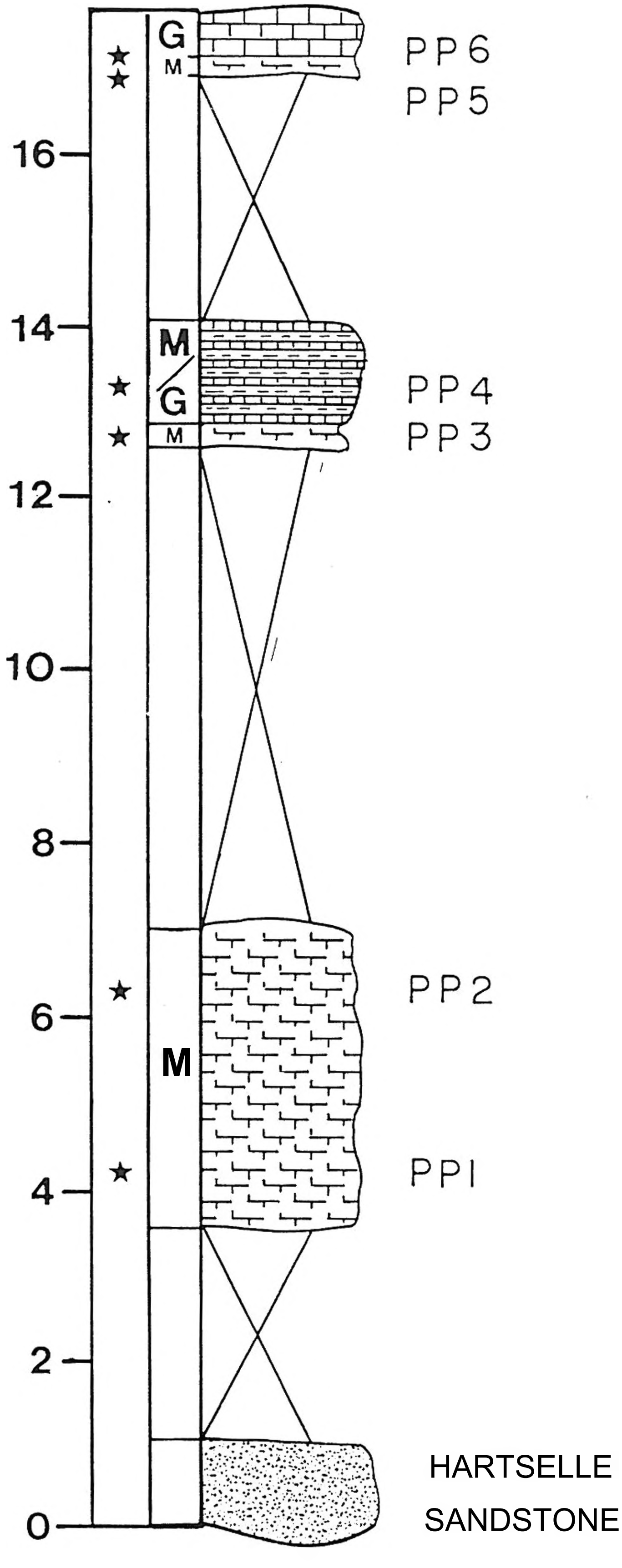


Figure 9 : Pilgram[1] s Place Section

MOUNTAIN STAR

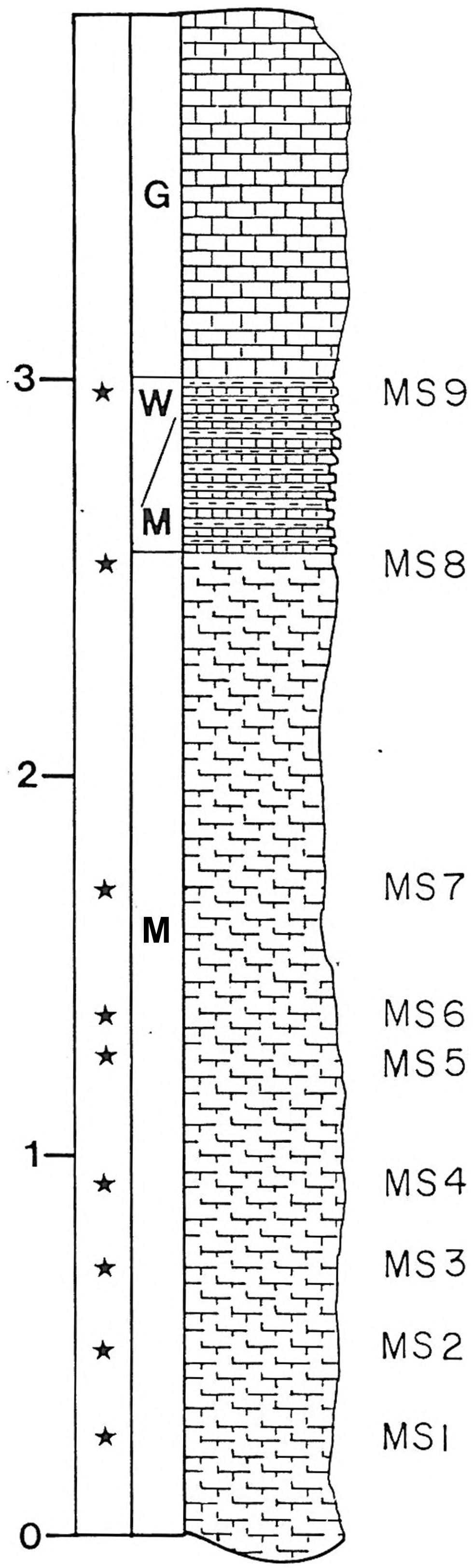


Figure 10 : Mountain Star Section

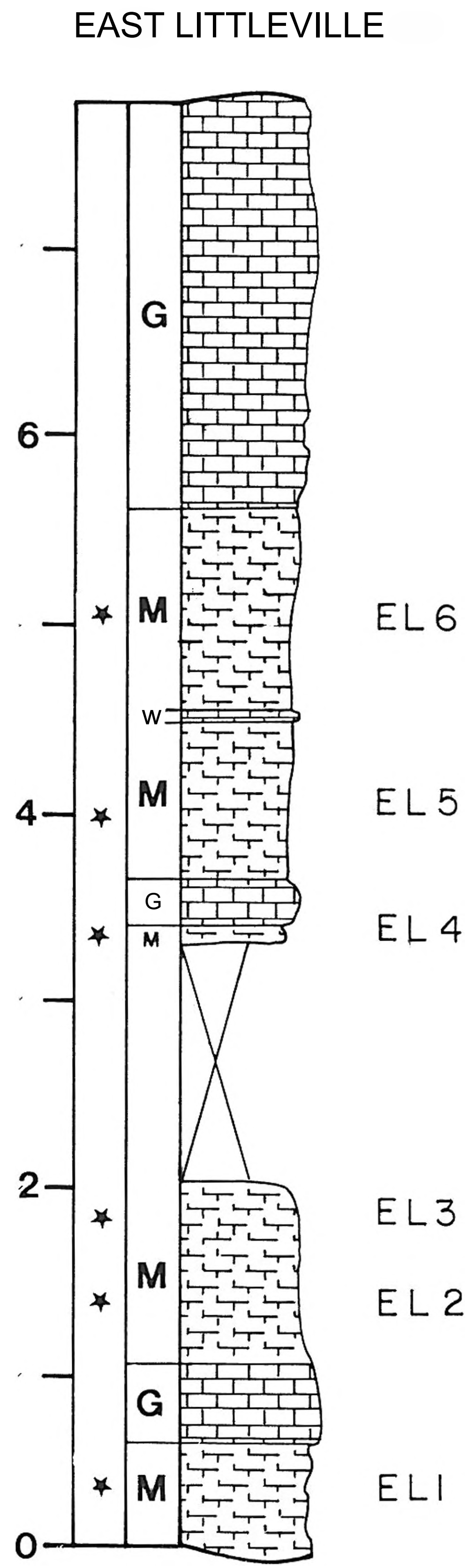


Figure 11 : East Littleville Section

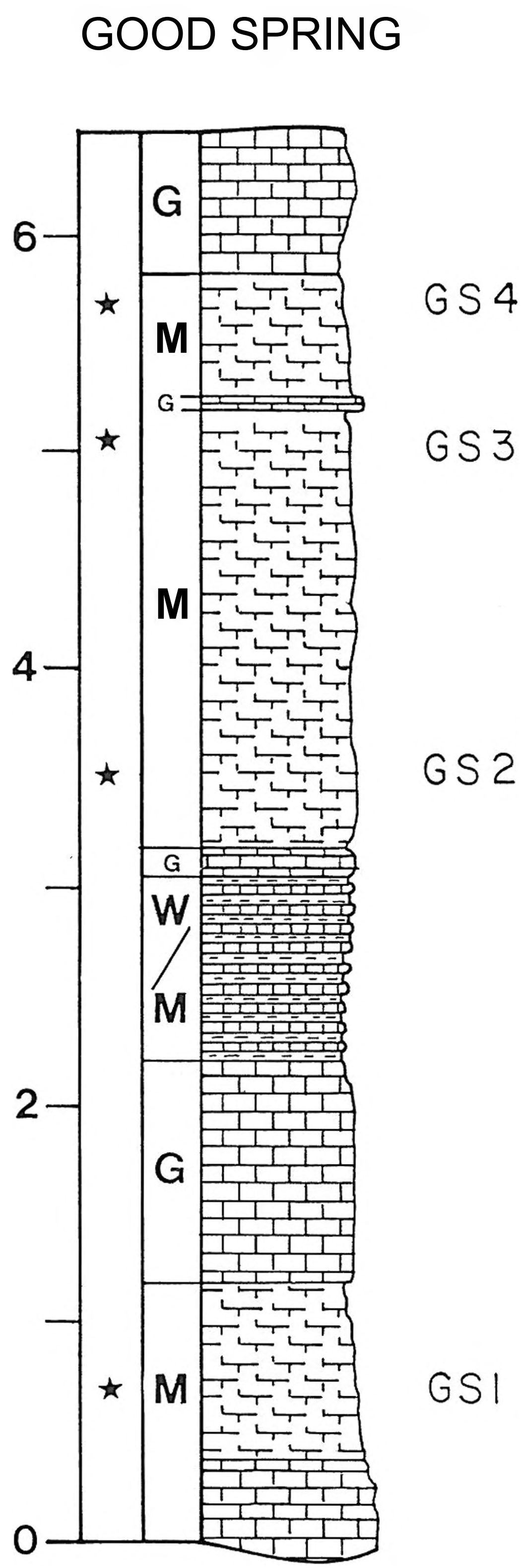


Figure 12 : Good Spring Section

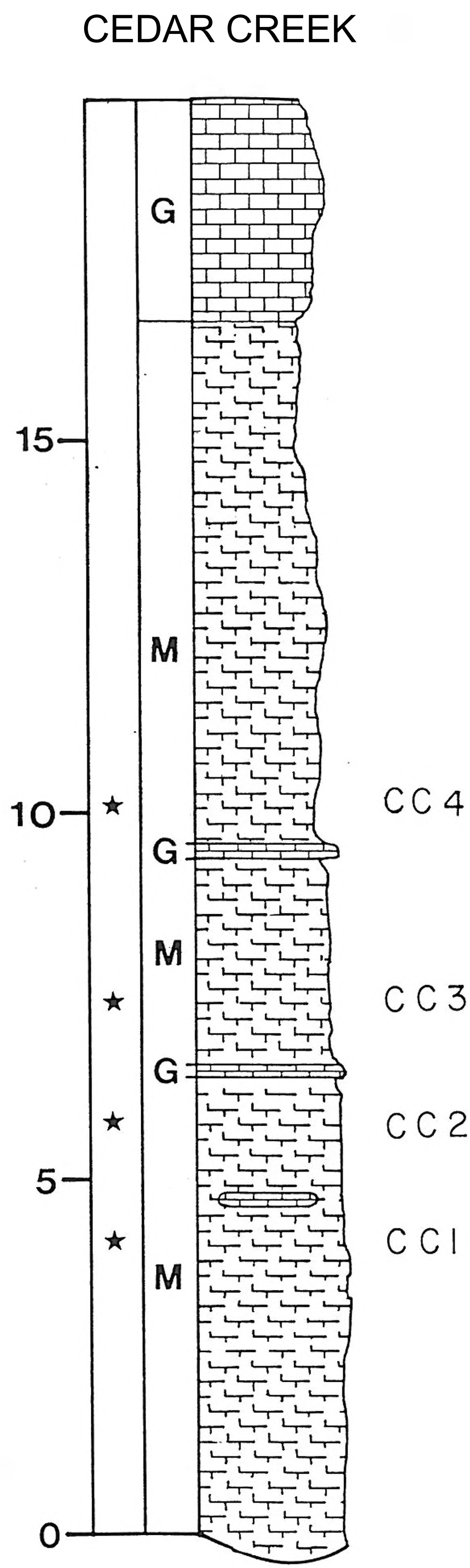


Figure 13 : Cedar Creek Section

lithofacies often contains thin, impersistant grainstone to wakestone horizons (e.g. 5—10 m interval at Cedar Creek). Some of these units can be very useful marker beds (e.g. thin trilobite packstone at 0.8 m level. Mountain Star). Small spiriferid brachiopods, gastropods and crinoids are common macroinvertebrate remains along with various (as yet) unidentified ichnofossils. This lithofacies is interpreted as the distal end of the Floyd depositional system.

ii) Interbedded Mudstone—Wackestone Lithafacies

This lithofacies consists of centimetre thick interbeds of wackestone and calcareous shales or silts. The wackestone may grade to packstones and are typically fenestrate bryozoan — peimatozoan rich units. The interbedded lithofacies is never more than 0.5 m thick and probably represents short lived fluctuating conditions.

iii) Grainstone Lithofacies

This lithofacies is the most variable of those studied, and includes massive, well cemented, bioclastic packstones and grainstones. The most common asssociation is poorly sorted biosparitic brachiopod - fenestellid — peimatozoan packstones to grainstones, although oolitic horizons are sometimes present (e.g. 10 m interval at Foxtrap) .

b) Depositional Environments

The measured sections at East Littleville, Mountain Star, Foxtrap and Pilgram's Place are located close to the western edge of the East Warrior Platform (Thomas, 1972). The Good Spring section is located just west of the platform edge and the Cedar Creek is some distance from the platform edge. From this perspective it is expected that from east or west the sections should exhibit increasing influence from the Floyd clastic wedge. Conversely from west to east the sections should show increasing influence of the carbonate platform. The more massive sediments of the Grainstone Lithofacies were deposited as carbonate shelf sediments (Thomas, 1972; Wilson and Jordan, 19Ö3). In the region of the East Warrior Platform these units represent "normal" conditions, and to the west of the platform, the presence of the Brainstone Lithofacies may indicate transgressive pulses. Waters (1978) used megafaunal associations to delineate "nearshore" and "offshore" assemblages, using echinoderm packstones as markers for maximum transgressive extent at each i ocali ty.

The effect of the prograding Mississippian clastic wedges, was to choke off carbonate production. The fine grained sediments being deposited at the distal (prodeltaic) end of the system created environments that were too turbid for the filter feeding bryezoans and pel matozoans, and/or the carbonate secreting algae.

The stratigraphic sections therefore result from the interaction of prograding prodelta environments and a transgressive carbonate platform. Vertical changes in lithofacies are attributed to localized environmental changes associated with progradation and/or transgression.

c) Dstracode Bio-facies

CH the 34 ostracode samples collected, cani y 5 were completely barren (PPI, PP2, EL2, EL3, CCD. From the remaining samples a very abundant and diverse, typically mid-continent ostracode fauna has been described (cf - Cooper, 1941; Sohn, 1975, 1977). The taxonomic details for the fauna have not as yet been resolved. Preservation of the fauna is so good that at normal working magnifications of the S.E.M. (70—20ÖX) , there is virtually no apparent diagenetic alteration. This means that many of the species described by Cooper (1941), Coryell and his students (1928, 1931, 1932, 1933, 1938, 1939, 1942) and Croneis and his students (1938, 1939), may be re-evaluated and some of the much needed taxonomic revisions begun. The revision of Bairdia (Sohn, 1960; Jones, 1975); amphissitids and related genera (Sohn, 1961) and the paraparchitaceans (Sohn, 1971, 1972); as well as the hoi 1 i nomorphs (Bless and Jordan 1971, 1972) only serve to underscore the amount of taxonomic work needed for a full understanding of Late Palaeozoic ostracodes. This is nowhere as marked as within the Superfamily Kloedenellacea.

Ostracodes derived from the lower Bangor include the following genera from various taxonomic groups:
Bairdiaceans are very common and include a number of species of Bairdia, Rectobairdia, Bairdi ol i tes, Bairdiacypri s and Acratia. The only hollinacean is Tetr asaccul us mirabilis, although other palaeocopes such as the kirkbyaceans include Polytylites spp, Amphi ssi tes, Ki rkbya and Revi ya. Paraparchitaceans include

Chámishael1 a, Shivaella and Shishaella although the group as a whole is not very abundant. Healdia spp., Seminolites, Bythocypri s. Cavei lina and Paracavel 1 i na can be locally important as can CornjgeM , KirkbyelД a, Moorites, Ypun.g.i el_la and Б1yptopleuroi des» Monoceratina is a soft substrate dweller (Donze, 1971; Sakae, 1977) and several species occur in the lower Bangor- Coryelli na is the only form to have a known stratigraphic significance (Sohn, 1962; Sohn and Jones, 1984). Much rarer components of the fauna include Pseudoparaparchites, Polycope, Libumella, Tri cerati na and Mi crochel1 inella. The single most important and taxonomically most complex group in the Bangor is the Kloedenel1 acea. This superfamily includes Geisi na, SargentAT!a SPP · 5 Nuferei 1 a spp. , Geffenina spp , Gl yptopl eura spp., Glyptopleuri na spp- ,................................ Beryri chi opsi s and the very distinctive forms ?Evlanovia and Chesterella of questioned kloedenellacean affinity.

Using these groups, 4 distinct ostracode biofacies can be defined:

i) Bairdiacean dominated biofacies

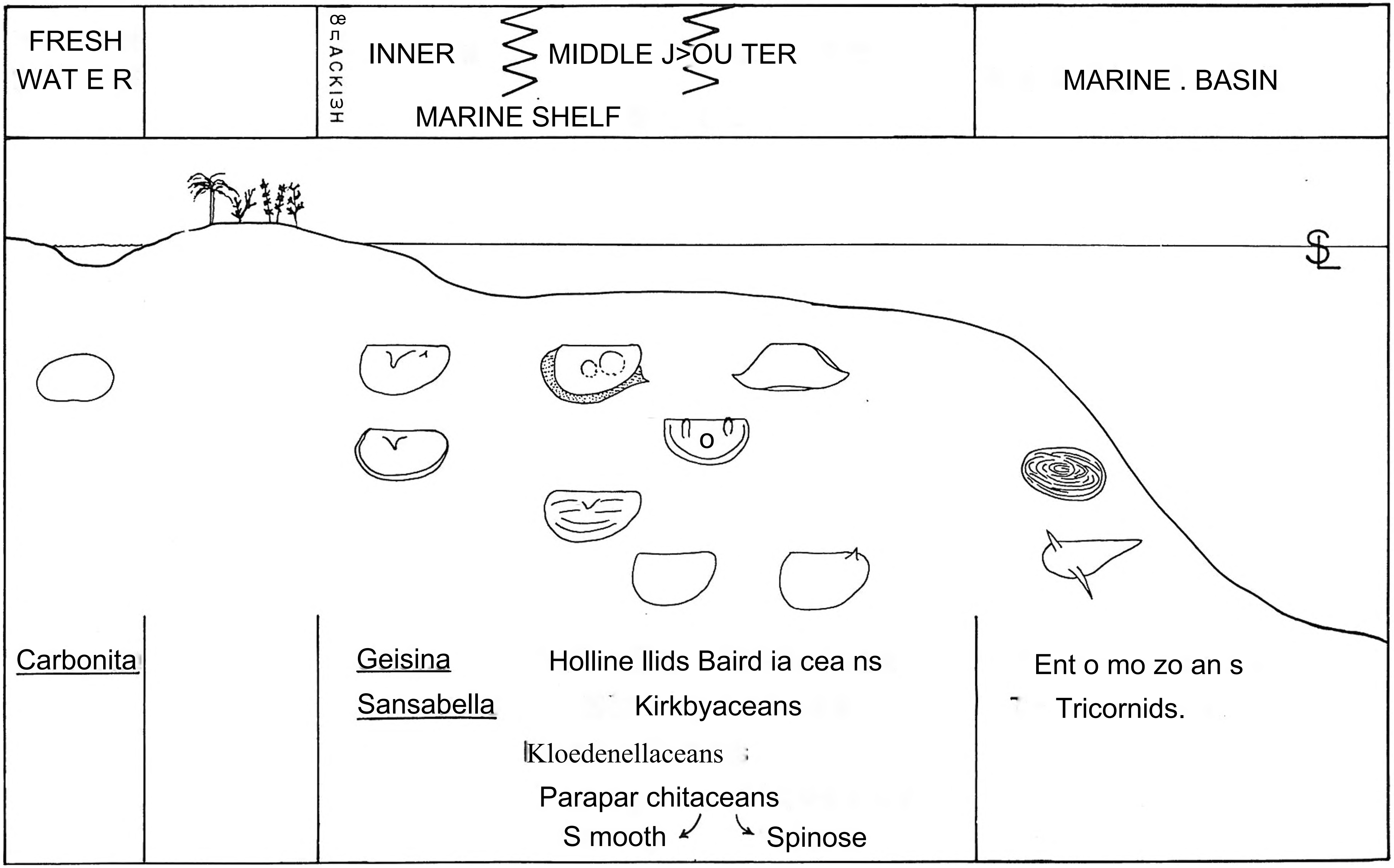
i i) Polytyli tes and bairdiacean biofacies

iii) mixed Bairdia and kloedenellacean bi of acies

iv) kloedenellacean bi ofacies dominated by Sarqentina, Nueferei 1 a and Geffenina

An environmental index of Carboni f erous ostracodes (Fig-14), modified from Bless (1983) shows that in a general sense, ostracode bi ofacies are bathymetri cali y defined. The presence of the stenohaline bairdiaceans in a fauna is thought to indicate

Figure 14: Environmental Index of Carboniferous Ostracodes



offshore conditions of normal marine salinities (Kornicker, 196í, Bless, 1983). In contrast presence of Geisina is related to reduced salinity marine, brackish or even freshwater conditions (Pollard, 1966). Dominance of kloedeneliaceans in a fauna may be related to confined or restricted environments (Crasquin, 1984). The presence of paraparchitaceans is generally thought to indicate nearshore environments (Sohn, 1971, 1972; Bless, 1983), but may also be indicative of hypersaline conditions (Dewey, 1983, 1986).

From these data it is clear that depth is not the controlling factor, and it is likely that Carboniferous ostracode bio-facies from the Bangor may be controlled by salinity, turbidity, clastic supply, substrate, circulation and sea level fluctuation. As these factors interact, it is reasonable to expect that ostracode bi ofacies boundary would be gradational except where sudden environmental changes occur.

Work in the Bangor Limestone shows that ostracode biofacies do not conform to obvious lithofacies boundaries and may therefore be useful for determining environmental changes that are not recorded in the sedimentary record.

Preliminary results of biofacies analysis indicates that the K1oedenellacean dominated Biofacies is recognised throughout the Cedar Creek section, which is the longest section of the proděl taie Mudstone Li thof acies. The Kloedenel1acean Biofacies is also noted at Mountain Star (MS 4, 5, 6, 9).

The mixed Bairdia—kloedenel1acean Biofacies occurs at Mountain Star (MS 1, 3, 7, 8) and Foxtrap (FX 1). The

Pol ytyl i tes—bai rdi acean Biofacies occurs at Pi Igram's Place (PP. 3, 4, 5, 6). The Bairdiacean Bio-facies occurs at Foxtrap (FX 2, 3) and Mountain Star (MS 2). Although the bairdiacean related bio-facies are more common on the East Warrior Carbonate Plat-form, the effect of clastic influx resulted in a mixed Bai rdi a—kloedenel1acean biofacies at both Mountain Star and Foxtrap.

One of the best examples of non-lithological iy evidenced, environmental changes from the present data is the 0—2.6m interval at Mountain Star. In this interval, eight ostracode samples were collected from lithologically identical sediments. The section begins with the mixed Bairdi a—kloedenel1acean biofacies and sample MS2 contains the bairdiacean biofacies prior to deteoriating to the kloedenel1acean biofacies at MS 3 & 4. At MS 5 only a few individuals of the kloedenel1acean fauna are present. At MS 6 an increase in abundance and diversity is noted which continues through samples MS 7.

At MS 8 the fauna has returned to the mixed Bairda-kloedenel i acean biofacies. Since none of these changes can be related to any obvious lithological variation, it is clear that some other environmental parameter such as turbidity or salinity is affecting faunal distributions.

Due to the sheer size of the fauna collected and the taxonomic work yet to be completed, these results are considered preliminary and subject to modification as further material is processed.

Pottsville Bio-Facies

a) Measured Sections and Li thof acies

Biofacies analysis of the upper Pottsville in northwest Alabama was achieved by working with a series of measured sections along Highway 69 between Tuscaloosa and Cullman (Fig. 15). The highway approximates to a dip section through the entire upper Pottsville which made it possible to work with sections that together span almost all the inter—coal group intervals. Areas where overlap of section occur (Fig. 5) serve to demonstrate the amount of lateral variability in the 1i thofac ies.

The measured sections were correlated by field reference to major sand units and adjacent coal groups (Fig. 5). It was possible to confirm correlations using several sources (Culbertson, 1964; Metzger, 1965; Daniel, 1978; and Rheams and Benson, 1982). Further confirmation was possible through ongoing work at the Alabama Geological Survey (Rheams, pers, comm.).

In total, more than 450m of section was measured and sampled for macroinvertebrate fossils. Most of the sampled strata was from the inter—coal group sediments. Highway 69 is cut by an number of stream valleys, which afford excellent exposure, and comparison of opposite valley walls was useful in determining the amount of lateral facies continuity.

The detailed bi ofacies analysis is part of an ongoing MS thesis at M.S.U. From north to south, the measured sections were

1 : BREMEN

2 : WOLF CREEK

3 : INDIAN CREEK

4 : LITTLE YELLOW CREEK

5 : BLUE CREEK

6 : TURKEY CREEK

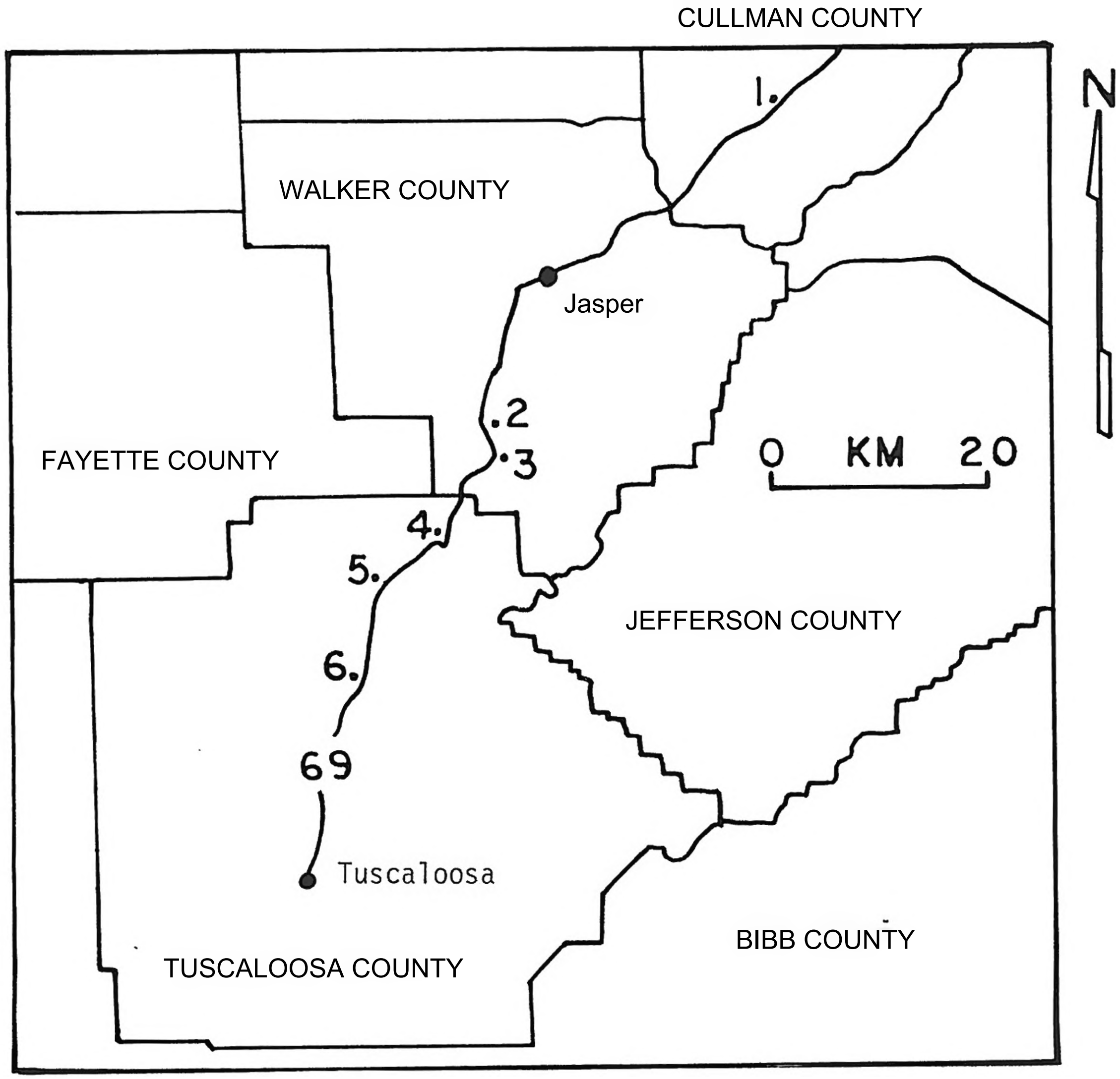


Figure 15 : Location of Pottsville Outcrops used for Macrofossil Analysis

as follows:

i) Bremen Roadcut (Fig. 16)
S 1/2 N 1/4, Sec. 11, T12S, R4W on highway 69, 25 miles north of Jasper.

ii) Wolf Creek Roadcut (Fig. 17)
W 1/2 W 1/2, Sec. 9, To SE 1/4 SE 1/4, Sec. 8, T16S, R8W, 19 miles south of Jasper.

iii) Indian Creek Roadcut (Fig. 18)
E 1/2 SW 1/4, Sec. 27, T16S, R8W roadcut on east side of highway, south of Indian Creek.

iv) Little Yellow Creek Roadcut (Fig- 19)
SW 1/4 NE 1/4, Sec- 18, T17S, R8W, 30 miles north of Tuscaloosa, immediately south of Little Yellow Creek.

v) Blue Creek North Roadcut (Fig. 20)
NW 1/4 SE 1/4, Sec. 33, T17S, R9W
Blue Creek South
E 1/2 SW 1/4, Sec. 33, 24.5 miles north of Tuscaloosa on both sides of Blue Creek.

vi) Turkey Creek North Roadcut (Fig. 21)
NW 1/4 NW 1/4, Sec. 8, T19S, R9W
Turkey Creek South
SE 1/4 NE 1/4, Sec. 7, 14.5 miles north of Tuscaloosa on both sides of Turkey Creek.

The sections can be subdivided into about four major litho— facies, which may be summarized as follows.

i) Subgreywacke Lithofacies

This lithofacies is composed of predominantly grey, silty, micaceous, fine to medium grained sandstones. The lithofacies is often associated with a coal group and may occur as a single sequence of beds or as a group of beds that is interbedded with the siltstone-shale lithofacies. An example of the former is found at Wolf Creek, in the 50-55m interval where the Camp Branch Sand underlies the Cobb Coal seam- The position of the Cobb Coal in this interval was confirmed by Rheams (pers- comm.). An

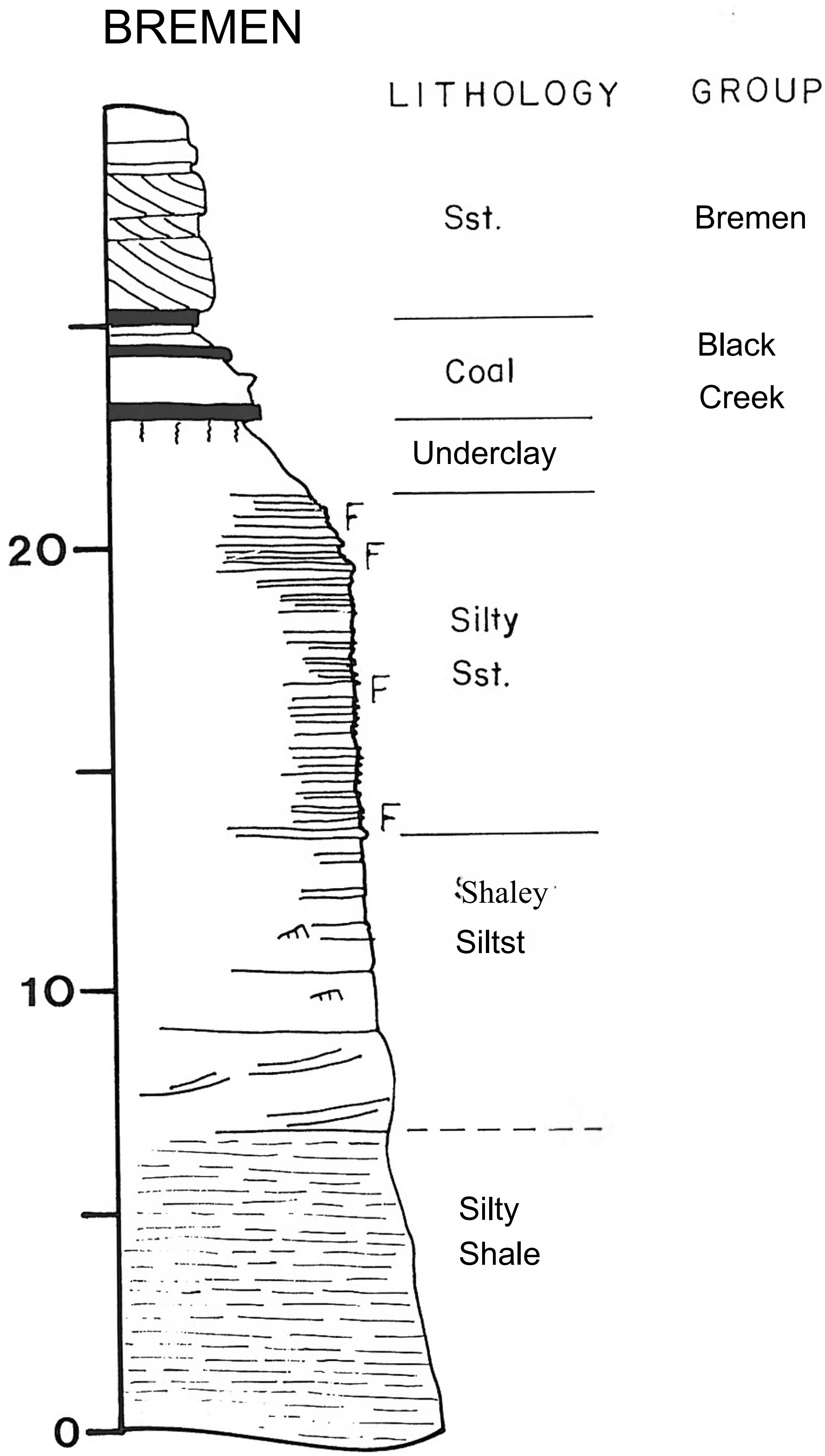


Figure 16 : Bremen Section.

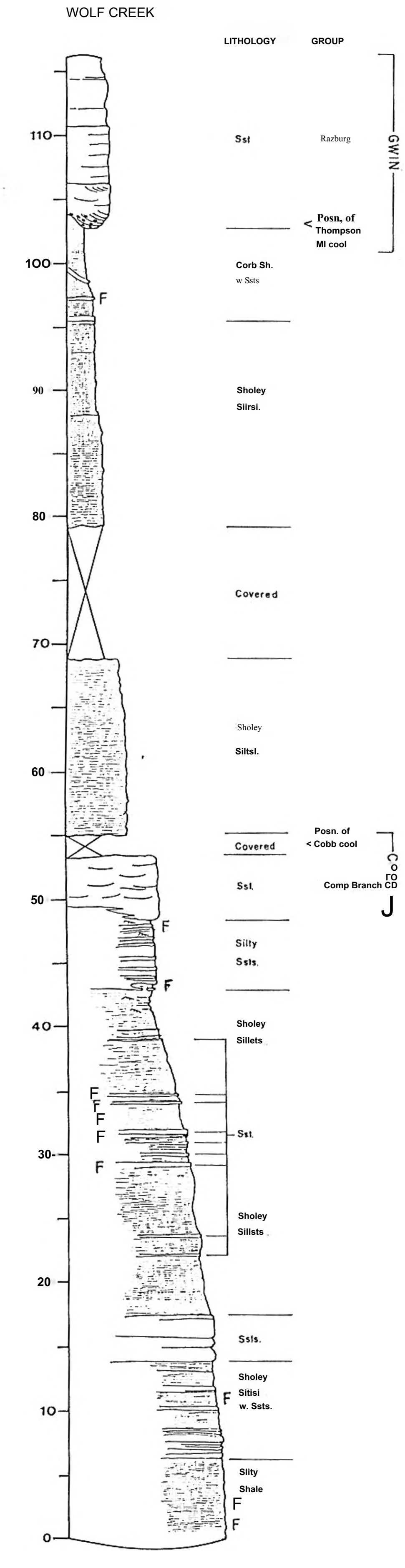


Figure 17 : Wolf Creek Section

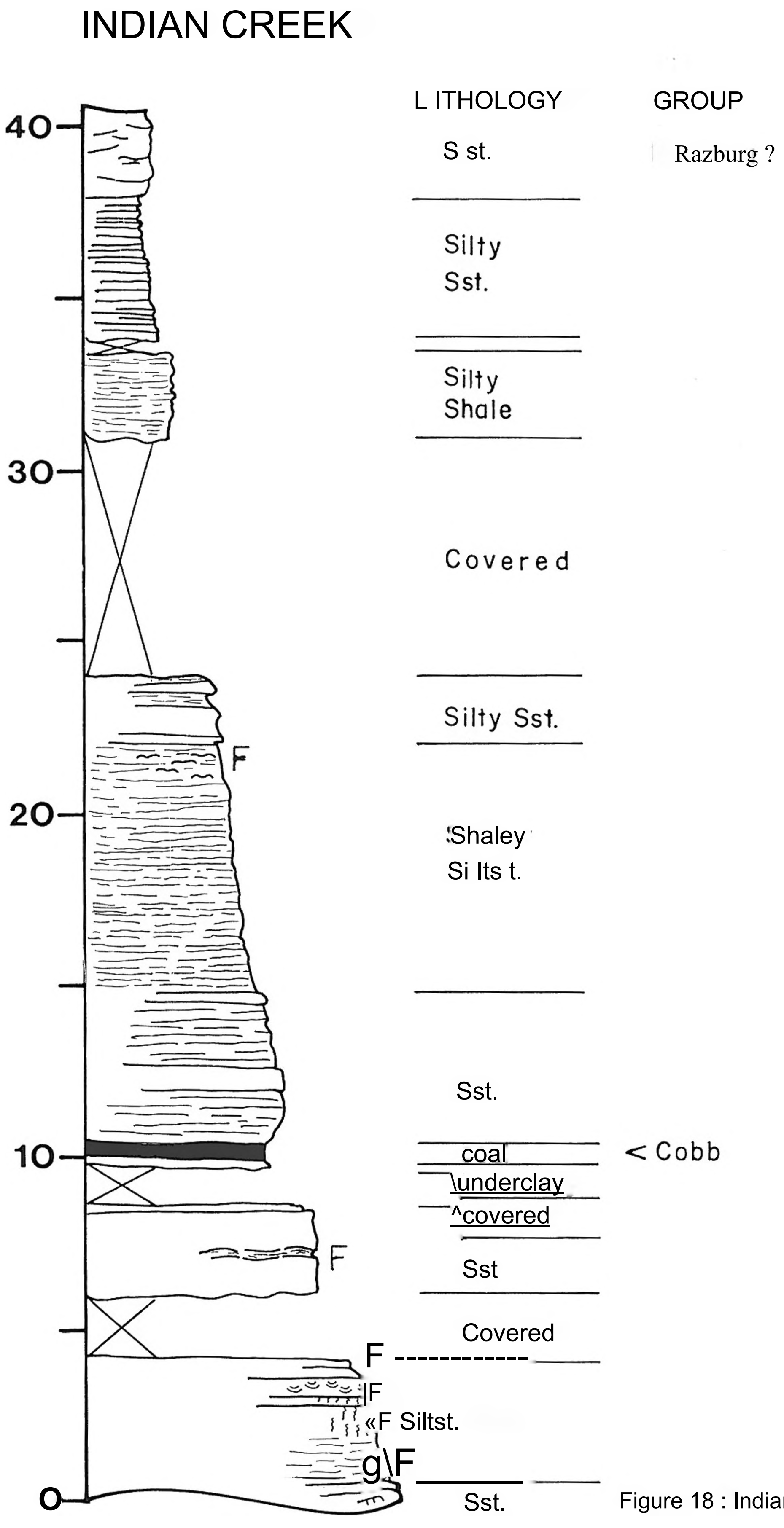


Figure 18 : Indian Creek Section

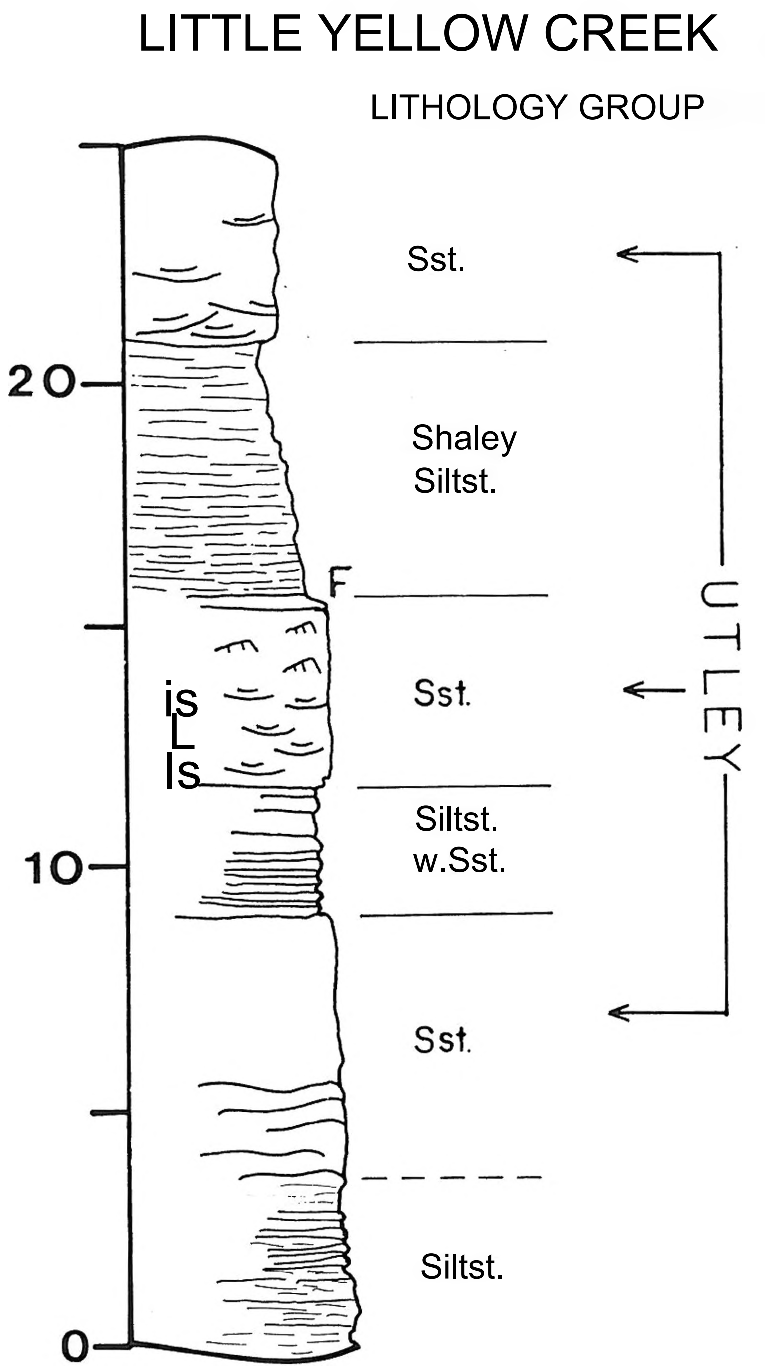


Figure 19 : Little Yellow Creek Section

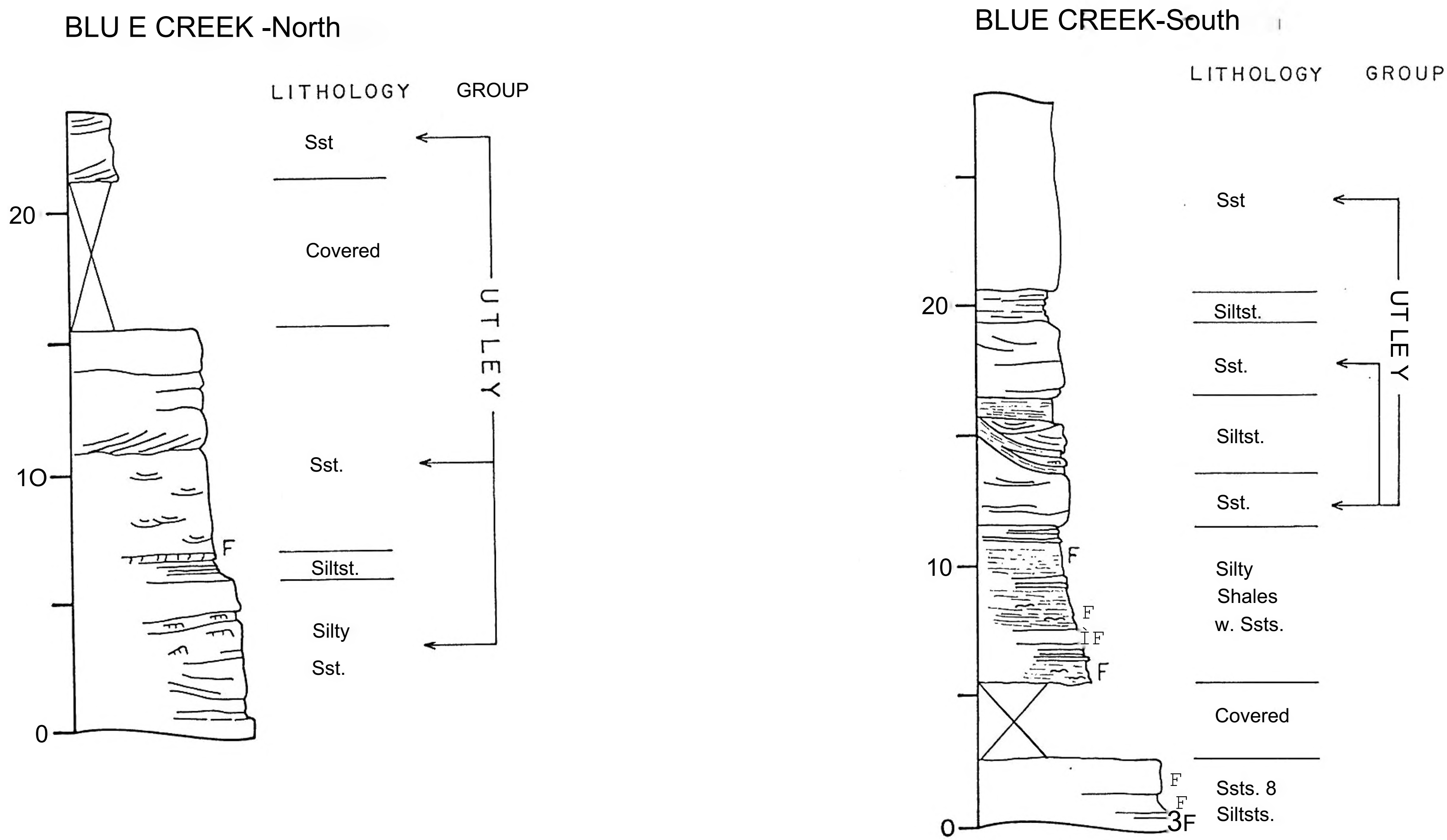


Figure 20 : Blue Creek Section

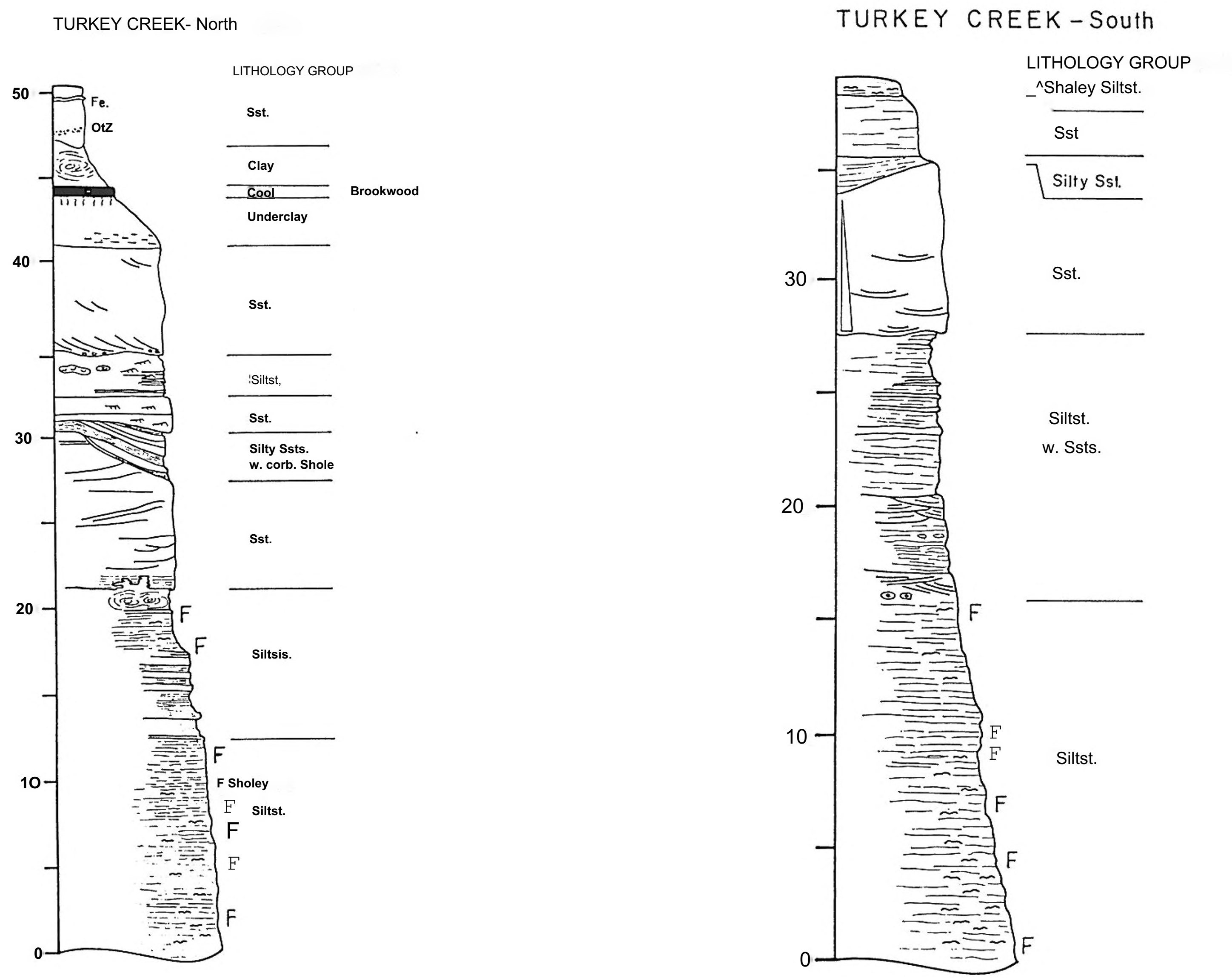


Figure 21 : Turkey Creek Section .

example of the latter is found at Little Yellow Creek where the three units of the Utley Sand are separated by siltstone-shale intervals.

A variety of sedimentary structures occur in the subgreywacke lithofacies; these include horizontal laminations, low angle cross bedding, trough cross bedding and climbing ripples. Macroinvertebrate fossils in the subgreywacke lithofacies can be found as part of a channel lag (Blue Creek, 7m interval), in a thin horizontally bedded fine—grained unit with inarticulate brachiopods (Bremen, 20m interval) and as a diverse fauna immediately below the si itstone—shale lithofacies (Little Yellow Creek, 15m interval.)

ii) Si 1tstone—Shale Lithofacies

This lithofacies is composed of dark grey micaceous, shaley siltstones and silty shales- Bedding is poorly developed and most sections show an irregular discontinuous lamination- Thin si deri tic bands up to 3cm thick are common (Bremen, 15—20m interval). Plant debris may be sparee to common, and a sparee invertebrate fauna occurs throughout most exposures of this lithofacies. Faunal distribution is vertically uneven. A mottled texture, which is indicative of bioturbation, as well as evidence of burrowing is common (Turkey Creek South, 0—7m i nterval).

Subordinate lithological associations in this lithofacies include fine-grained, micaceous sandstones, micaceous siltstones and black shales. The sandstones can vary from a few centimetres to 1.5m in thickness and may show horizontal laminations or climbing ripples. The sands may be bioturbated (Indian Creek, 2m interval), fossiliferous (Blue Creek South, 0-2m interval) or barren (Indian Creek, 22m interval). The micaceous siltstones may be horizontally laminated or trough cores bedded. The black shales are fissile and mostly devoid of fossils, except for some plant debris.

iii) Quartzose Sandstone Lithofacies

This lithofacies is composed of grey medium to fine-grained quartz rich sandstones. It is only found at one locality (Bremen, 26—30m interval). At this locality the lithofacies is composed of a number of 30—150cm thick planar cross set packages. They indicate a southward palaeocurrent direction. At the base of the lithofacies is a flat pebble conglomerate containing siltstone clasts.

iv) Coal and Underclay Lithofacies

A coal and underclay lithofacies is exposed at three localities (Bremen, Indian Creek and Turkey Creek North). At Bremen it underlies the Quartzose Sandstone Lithofacies and at Indian Creek and Turkey Creek North it is associated with the Subgreywacke Líthofacies.

The underclays are grey massive plastic clays that may be rooted to a depth of 30 cm. They coarsen downward into silts and very fine sands. The coals are either laminated (Bremen) or blocky (Turkey Creek). At Bremen the coal horizon is interbedded with grey and black silty shales and fine—grained sands.

b) Depositional Environments

in the Pottsville Formation of northern Alabama it is difficult to relate lithofacies to environments because similar depositional processes prevail in different envi ronments.

The lithofacies described from measured sections along highway 69, can be ascribed to four main delta related environments. A discussion and review of deltaic environments in the Pottsville is given in Horsey (1981) and Rheams and Benson (1982).

The Subgreywacke Lithofacies is associated with distributary systems (channels, mouth bars, levees, and crevasse splays) of a delta. Not all the sandstones represent either the same parts of, or the same energy levels within such systems.

Some sand units of the Subgreywacke Lithofacies show good fining upwards sequences and are interpreted to be channel sands (e.g. 28—32m interval at Turkey Creek South and 2—15m interval at Little Yellow Creek). Not all the suggested channel sands have erosive lower contacts, however the Razburg Sand (Wolf Creek, 103m interval) is erosional and has a lithoclastic lag deposit at the base. Rheams (pers, comm.), suggests that at this locality the Razburg has cut through the level of the Thompson Mill Coal of the Gwin Coal Group. A mixed bio— and lithoclastic channel lag occurs at Blue Creek (7m interval).

The only sandstone units that may represent mouth bar deposits include 21—30m level sand at Turkey Creek North, and the basal Utley Sand at blue Creek (Fig. 20). The mouth bar sands are all thickly bedded and at Turkey Creek North there is a gradational change of sedimentary structure from planar bedded at the base, through trough cross bedding to rippled at the top» The top of the unit is incised by a silty sand and silt channel fill deposit as is the basal Utley Sand at Blue Creek South. If these sand bodies are mouth bar deposits, then the underlying siltstones with thin sands (Turkey Creek North, 12—20m interval, Blue Creek south, 6—12m interval) may be distal bar deposits.

The thin sands interbedded with the Siltstone-Shale Lithofacies probably represent short lived low energy distributary branches or the distal ends of more extensive branches, the lack of erosive basal contacts attests to their low energy status. It is also possible that the thin sands may also represent distal parts of crevasse splays or storm deposits.

The Siltstone-Shale Lithofacies is interpreted as representing prodelta lagoon and/or interdistributary bay deposits. The lithofacies is typically fine—grained with a sparse marine fauna. In places the fauna may be diverse and abundant, but in such cases there is a vertical gradation into a more restricted fauna- It is often difficult to differentiate between examples of the lithofacies that represent lagoonal vs. interdistributary bay environments (Rheams and Benson, 1982). One of the mitigating factors is salinity. An isolated lagoon may exhibit brackish conditions and a large open inter-distributary bay, a long way from a distributary channel may exhibit near normal marine salinities. The presence of a marine fauna is therefore not necessarily indicative of either prodelta lagoons or interdistributary bays on the lower delta plain- Lithologically, lagoonal deposits are generally -finer grained but this is an insufficient criterion for recognition. The presence of extensive bioturbation, thinly bedded laminations, sideritic bands and predominance of siltstones over shales may, in combination with faunal factors described above, indicate interdistributary bay environments. A further method which would aid di fferentiation is by lithological association, but lobe switching and channel migration can make stacked lithological associations very complex.

The Quartzose Sandstone Lithofacies at Bremen is currently the subject of an MS thesis at Auburn University. Rheams and Benson <1982) interpreted the Bremen Sandstone as a barrier island deposit, similar in nature to the lower Pottsville Boyles Sandstone described by Hobday <1974). Haas and Gastaldo <1986) suggest that the Bremen Sandstone represents a flood tidal delta deposi t.

The Coal—Underci ay Lithofacies can be ascribed to various palaeoenvironments. In the generalized model of Ferm et.al. <1967), coals in the Black Warrior Basin formed in back barrier and both lower and upper delta plain environments. The Black Creek Coal is interpreted as a barrier—related coal (Rheams and Benson, 1982? Haas and Gastaldo, 1986). The Brookwood Coal (Turkey Creek) and the Cobb Coal <Indi an Creek) are lower delta plain coals.

c) Bio-facies

In this investi gáti on, three distinct, but intergradational indigenous -faunal assemblages (Fig. 22) have been recognised (Body and Dewey, 1986). A single exogenic assemblage is also recognized.

i) The Productid Assemblage

This assemblage is a diverse association of articulate brachiopods, bivalves, gastropods and crinoids together with rare trilobites and bryozoans. Corals are noteable by their absence. Burrowing is commonly indicated by a mottled texture although Heimi nthapsi s trails may be quite abundant. The assemblage is the most diverse assemblage studied and occurs in the Siltstone-Shale Li thofaci es (e.g. Turkey Creek North, 0—10 m interval) and in the upper portions of the Subgreywacke Lithofacies (e.g. Little Yellow Creek, 16 m interval), where it is overlain by the Si itstone—Shal e Lithofacies. The occurrence in both lithofacies appears to indicate faunal independence of substrate grain size control.

The assemblage is thought to be indigenous because the bivalves and brachiopods are articulated and the latter often possess long, delicate spines. (These often break once the enclosing fine-grained matrix dries). Disorientation of brachiopods in the sediment may be a function of post-mortem bioturbation (Fursich, 1978). Although no calyxes have been found, crinoid stems up to 18 cm in length would also suggest minimal transport.

TAXA	...SSEMBLAGE / EC... OIDEA	GORe,Eo-/SSOCHoNe...ES	PRODUCTID
LINGULA	●		
ORBICULOIDEA MEEKANA	●	9	
EOLISSOCHONETES		9	●
LINOPRODUCTUS			●
ANTIQUATONIA			●
DESMOINESIA			●
HYSTRICULINA			●
ECHINOCONCHUS			9
COMPOSITA SUBTILITA			9
SCHIZOPHORIA RESUPINOIDES			9
SPIRIFERIDINE GEN. ET SR INDET.			9
NUCULA			9
PALEYOLDIA			9
WILKINGIA TERMINALE			9
TREPOSPIRA			9
PALADIN MISSOURIENSIS			●
BRYOZOAN			●
CRINOID OSSICLES & STEMS			●
ZOOPHYCOS		●	
HELMINTHOPSIS		●	●
SCALARITUBA			●
?ISOPODICHNUS .		●	●

Figure 22 : Pottsvile Macrofossil Assemblages.

Given the diversity and abundance of this assemblage a fairly normal marine environment is indicated, however the absence of corals and relative scarcity of crinoids and bryozoans does indicate the presence of environmental stresses such as turbidity or reduced salinity (Heckel, 1970)«

Occurrences of the Productid Asssemblage are found at the following locations: Turkey Creek North 0—10m interval
Turkey Creek South 0—9m interval
Blue Creek South 7m level
Little Yellow Creek 16m level
Wolf Creek 0-4m, 32m & 43m intervals
Indian Creek 2—4m interval
Bremen 14m level

ii) The Chonetid Assemblage

This assemblage is a low diversity, low abundance association, dominated by the chonetid brachiopod Eolis^ ochonetes morsei. It is found exclusively in the Siltstone-Shale Lithofacies, where it occurs mostly in shales but is also found in silts and sands which suggests some degree of grain size independence. The fauna is widely dispersed, giving exposures the appearance of being barren at first glance; it is however the most extensive of the faunas encountered. The brachiopods are articulated and still possess hinge spines, which suggests a lack of post-mortem transport.

The low diversity, low abundance nature of the fauna suggest environmentali y stressful conditions (Boucot 1981). The lack of stenohaline productids and crinoids suggests that salinity may be a controlling factor.

Bioturbation is similar to that of the Productid Assemblage except for rare occurrences of Zppphycps which are often found within the Productid Assemblage because of faunal mixing (Fursich, 1978) . That Zoophycos is part of the Chonetid Assemblage, can be demonstrated by the fact that the causiti ve organism carried sediment from the chonetid bearing levels down into the Productid Assemblage«

Occurrences of the Chonetid Assemblage are found at the following locations: Turkey Creek North 10—13m, 17—20m i ntervals
Turkey Creek South 9—lóm interval
Blue Creek South 0—2m, óm, 7—11m intervals
Wolf Creek 9—13m, 25—31m, 33—37m i ntervals
Indian Creek 0—2m, 21—22m intervals
Bremen 14—19m interval

iii) The Orbi cuipi dea Assemblage

This is a low diversity, low abundance assemblage of inarticulate brachiopods consisting mostly of Orbiculeidea and Lingula. It is the most restricted (brackish) assemblage and occurs above the Chonetid Assemblage- It is only known from the 19—21 m interval at Bremen.

iv) The Exogenic Assemblage

A mixed assemblage of broken but unabraided fragments of di sarti cuiated brachiopods and bivalves with gastropods occurs at two localities in the silty fine sands of the Subgreywacke Lithofacies. Associated materials in the channel lag deposits

(Blue Creek North and Wolf Creek, 49m level) include lithoclasts and plant debris.

Occurrences of the Exogenic Assemblage are found at the following locations: Blue Creek North 7m level
Indian Creek 7m level
Wolf Creek 49m and 97m levels

d) Discussion

A series of deltaic depositional environments and associated faunal assemblages have been described from exposed sections of upper Pottsville sediments along Alabama State Highway 69.

From the results presented, two important featrures are apparent. Firstly, neither lithofacies or biofacie5 are independently diagnostic of environment, and secondly, fossi i iferous horizons are much more extensive than previously reported (Metzger, 1965; McKee, 1975; Zei and Rollins, 1985).

The three indigenous assemblages are intergradational and this is clearly demonstrated by the vertical transition from the Productid Assemblage to the Orbicu^ Assemblage an Bremen idea (14—21m interval). The intergradation is considered to be a function of community replacement (Miller, 1986) due to subtle (detereorating) environmental conditions. The replacements occur when environmental parameters exceed the ability of an organism to adapt. Such replacements will be continuous, due to varying levels of adaptability demonstrated by individual species. There are several physical parameters that can control community reorganization which include (but are not limited to) salinity, substrate and turbidity (Jones, 1951; Boucot, 1981).

There is a transition from Productid to Chonetid Assemblages up section which can be related to the proximity of distributary system lithofacies (e.g» O—31m interval, Turkey Creek; 7— 15m interval. Blue Creek South). It has also long been recognized that orbi cuioidea—type communities are associated with brackish or restricted conditions (Moore, 1929; Elias, 1937; Williams, I960; Ferguson, 1962; Johnson, 1962; Bretsky, 1969; Hickey and Younker, 1981; Bibsen, 1985). Therefore, it is tempting to assume that gradational replacements -from the productid to the Orbi cuioidea Assemblage and the associated reduction in diversity may be a salinity controlled phenomen (Hecker et.al., 1963; Heckel, 1970).

. It is also clear from -faunal association changes occurring within homogeneous lithological packages (e.g. 0—12m interval, Turkey Creek North; 14—21m interval , Bremen) that -faunal changeovers are not directly controlled by substrate variations. This is further supported by the occurrence of an assemblage in more than one lithofacies. As an example of this, the Productid Assemblage occurs in the Subgreywacke Lithofacies (16m level, Little Yellow Creek) and the Si i estone—Shal e Lithofacies (0—10m interval, Turkey Creek North). Changes in assemblage may not be very distinct relative to changes in substrate because the grain size variation from fine sands to shales is not very great, and it is in these substrates that all of the indigenous fossils of the upper Pottsville in Alabama were found. It should however be

-Further noted that the Productid Assemblage mostly occurs at the base of a sedimentary package (e.g. Turkey Creek; 43m level at Wolf Creek) or at the top of a fine sand unit overlain by the Siltstone-Shale Lithofacies (16m level, Little Yellow Creek; 32m level, Wolf Creek). The occurrence of the most diverse fauna on top of fine sand units may be related to colonization of a slightly more favorable substrate during a hiatus in deposition. This would imply that pulses of higher energy activity which result in the deposition of thin sand horizons, may leave in their wake a favorable substrate for colonization, whereas continual availability of a stable low energy environment offering a silty substrate may not be quite as favorable to colonization (Broadhead, 1976). If the Siltstone-Shale Lithofacies represents interdistributary bay and/or prodelta lagoonal environments, then salinity will fluctuate according to proximity of a major distributary channel system providing a fresh water input. In the centre of a large interdistributary bay where freshwater effects are minimal and salinities may be closer to those of normal marine condition, the overriding control on diversity may therefore be subtle changes in substrate. Chonetid Assemblages are often associated with "offshore" or silty substrates (Williams, 1960; Johnson, 1962; Watkins, 1963; Stevens, 1966; Bretsky, 1969; Donahue and Rollins, 1974). Furthermore, Stevens (1966) working on early Permian strata from Nevada and Utah recognized that chonetid communities develop in quiet water environments that are too soft or too turbid for colonization by productids. Donahue and Rollins (1974) working with a Conemaugh transgressive event in West Virginia further suggest that chonetid faunas may reflect relict mature communities that result when only eurytopic organisms can survive environmental deterearation. Thus, in a large interdistributary bay or lagoon normal salinity, the eurytopic chonetids would colonize all available lithologies, but the more stenotopic productids would preferential 1 y colonize slightly firmer, coarser grained substrates.

It is therefore likely, from the evidence presented, that both salinity and substrate are controlling environmental parameters for faunal distribution. The question thus becomes, which is exerting the major control? The absence of corals and echi noi ds associated with the paucity of bryozoans indicates that environmental salinities were never at normal marine levels (35 ppt.). The presence of crinoids and productids however, would suggest that the salinity stress was not great. A comparison of upper Pottsville faunas of Alabama to other Carboniferous deltaic environments (Williams, 1960; Ausich et.al., 1979), reveals that overall diversity is lower for the Alabama faunas, which further supports the notion of salinity stressed conditions.

In conclusion, it is suggested that salinity was a major factor in controlling faunal assemblage development and replacement. It is also suggested that in a salinity stable environment Faunal assemblage character was controlled by subtle substrate grain size variations.

SUMMARY

A palaeontological study of the Carboniferous strata in the Black Warrior Basin employed ostracodes and macroinvertebrates to investigate palaeoenvironmental conditions. The results revealed a number of faunal associations, which, when considered with lithofacies are very useful for describing subtle environmental variations. Continued research will begin to place emphasis on the bi ostratigraphic usefulness of the ostracode faunas especi ally.

It is the ultimate intention of continued study to provide a more detailed predictive environmental model and stratigraphic framework for hydrocarbon exploration within the basin. The initial results are very encouraging and continued research is recommended.

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