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Use of Ostracoded in Analysis of the Black Warrior Basin II

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The Mississippi Mineral Resources Institute
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USE OF OSTRACODES IN ANALYSIS OF THE BLACK WARRIOR BASIN II

FINAL REPORT

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Institution:	Mississippi State University

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ABSTRACT

Continuing research involving Carboni ferous palaeontology of the Black Warrior Basin focussed upon the ostracode faunas of the Pride Mountain Formation.

Ostracode samples were collected from core materials in Itawamba County, Mississippi and Colbert County, Alabama and from outcrops in Colbert, Lawrence and Jefferson Counties, Alabama. Ostracodes from the Pride Mountain have provided a high diversity, variably abundant, mid-continent-type fauna. The preservation of the fauna ranges from excellent to poor.

Preliminary results indicate that ostracode assemblages from the Pride Mountain show some similarities with those of the Bangor, however there are distinct differences. The assemblages include:

a bairdiacean assemblage
a quasi 11i tacean-Amphi ssi tes-bi nodi cope assemblage
a kloedenel1acean assemblage.

Ostracode studies from the Bangor Formation acted as a basis for continued study in the Black Warrior Basin. The combined results from the study of ostracodes in the Bangor and the Pride Mountain has allowed for the recognition of palaeoenvironmental ly distinct ostracode assemblages. Mixed assemblages that occur in both the Bangor and the Pride Mountain demonstrate the gradational nature of ecological boundaries. A preliminary ternary diagram is presented as a working palaeoenvironmental model of ostracode faunas in the Black Warrior Basin.

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INTRODUCTION

i. General Remarks.

This report focusses on a study of ostracodes from the Pride Mountain Formation in northeast Mississippi and northern Alabama. As such it forms part of the Black Warrior Research Program, currently being conducted at Mississippi State University.

The Black Warrior Research Program is concerned with palaeontological, sedimentological and stratigraphic problems the results of which can be applied to an understanding of the distribution of economic reserves of coal, oil and natural gas in the Black Warrior Basin of Mississippi and Alabama. The program also has applications in aspects of basin development and palaeogeography.

The program can be divided into two main areas of interest: Firstly, the program is concerned with ostracode palaeoecology and biostratigraphy of the Mississippian strata within the basin. This aspect of the research is aimed toward providing a palaeoenvironmental and biostratigraphic tool that can be applied in the search for oil and gas reserves. Secondly, the program is concerned with the biofacies and lithofacies of the Pennsylvanian strata within the basin. This aspect of the research is aimed toward a better understanding of coal forming environments and their distribution within the basin.

The study profile for the Black Warrior Research Program (fig.I), provides an outline of the component projects for each of the major aspects of research. The initial research project (Dewey, 1986) served as the foundation stage for the two main areas of interest in the research program (fig.I); therefore this report represents part of the second stage in the development of the Mississippian ostracode studies. The second stage of the Pennsylvanian biofacies and lithofacies work is currently underway (MMRI Grant 88-4F).

ii. Location of Study Area

The study area was mostly situated within the outcrop belt of the Pride Moutain Formation in northeastern Mississippi and northern Alabama (fig.2). Outcrop locations were studied in Colbert, Lawrence and Jefferson Counties, Alabama. Material from three wells were also studied in Itawamba County, Mississippi, and Colbert County, Alabama.

Cities in the region include Tuscumbia and Muscle Shoals in Colbert County, Moulton in Lawrence County and

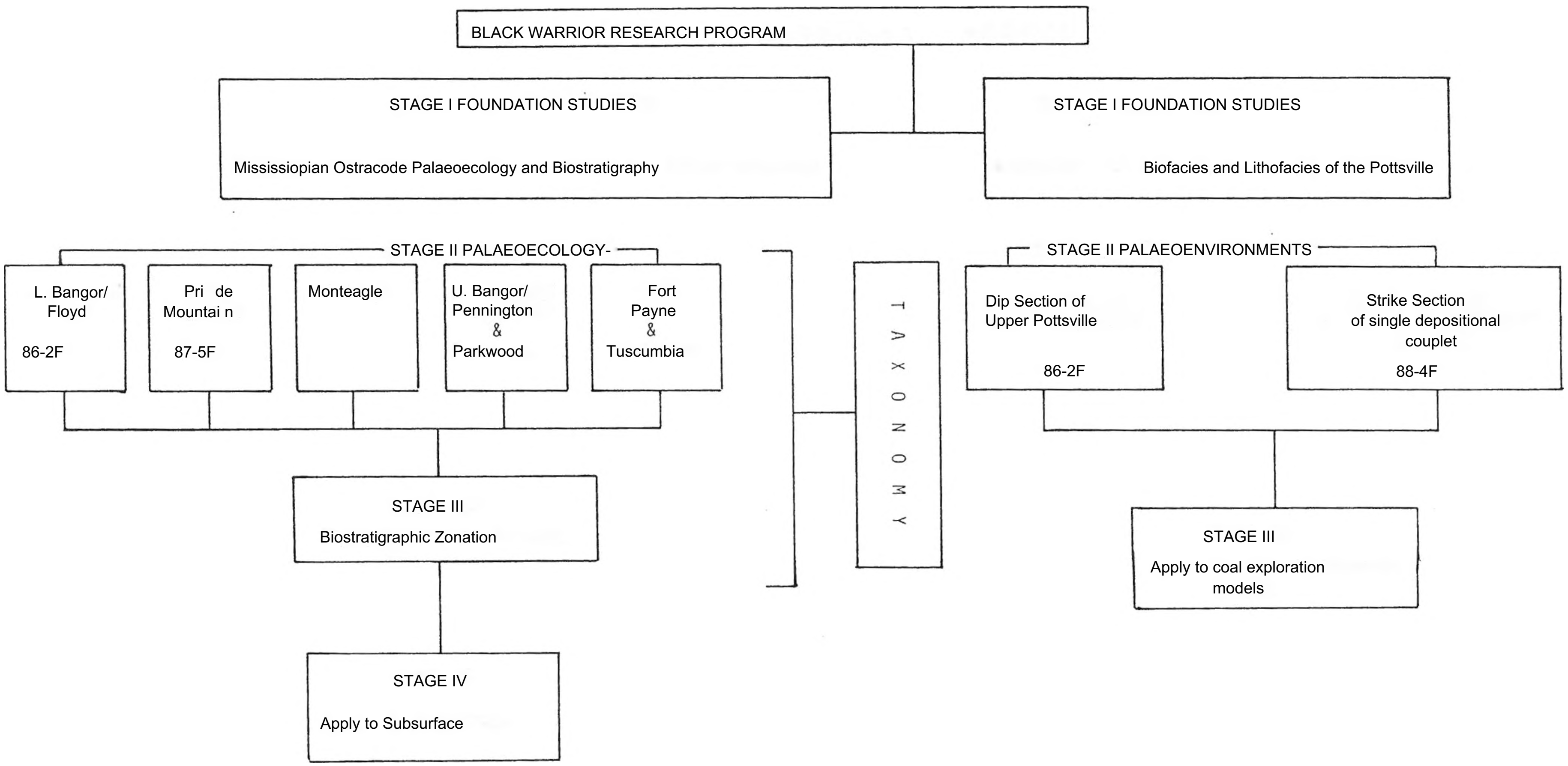
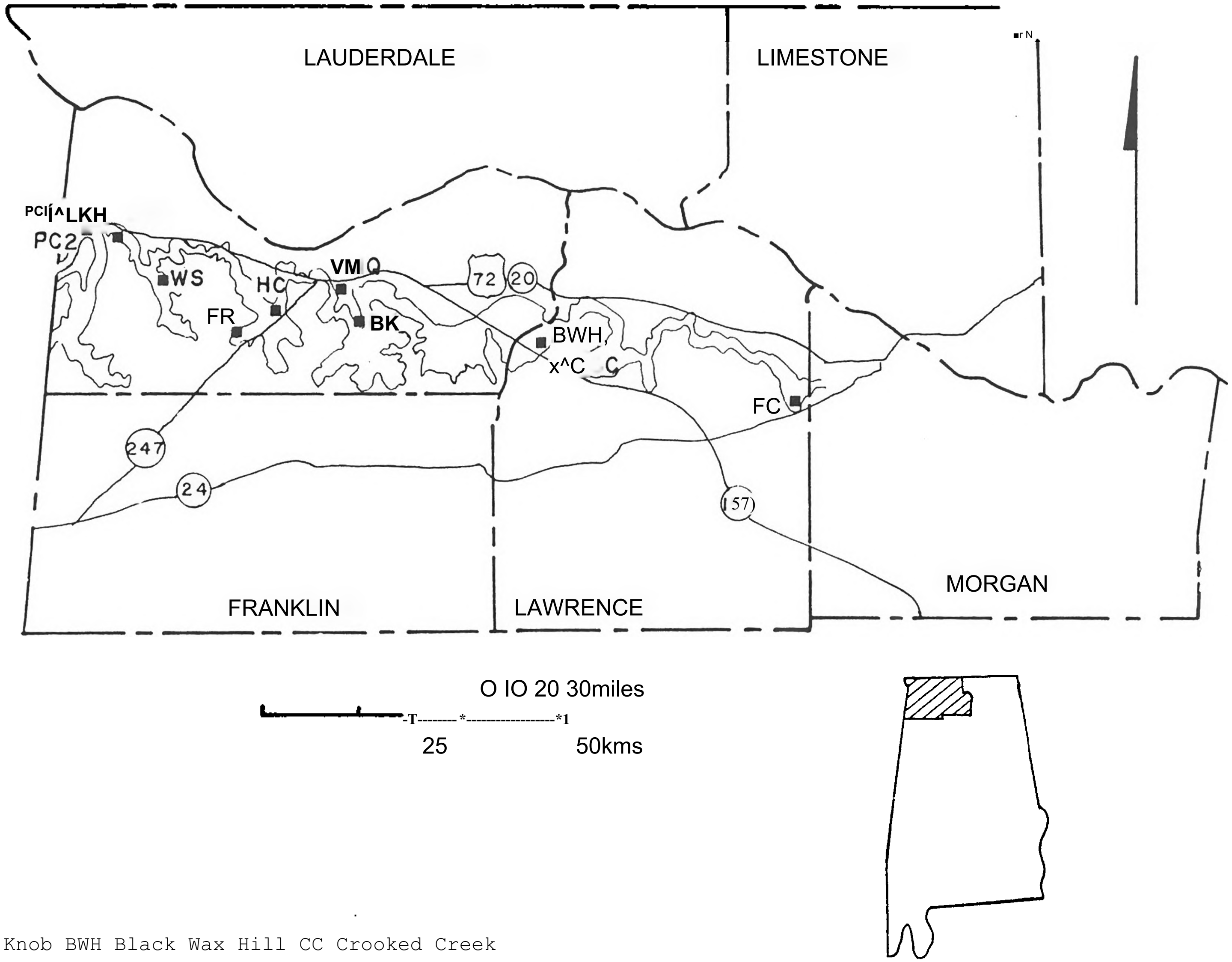


Figure 1: Components of the Black Warrior Research Program



BK Bald Knob BWH Black Wax Hill CC Crooked Creek
FC Fellowship Church FR Fielder Ridge
HC Henson Creek LKH Lime Kiln Hollow
PCI Pennywinkle Creek I PCII Pennywinkle Creek II
VMQ Vulcan Materials Quarry WS Williams Spring

Quarry í Tpfferson Co)

Birmingham in Jefferson County. The field area is traversed by a series of U.S. Interstate and Mississippi and Alabama State Highways as well as a network of lesser county and secondary roads.

iii. Physiography

Outcrops of the Pride Mountain Formation which comprise the main locations for this study, occur within two physiographic regions of northern Alabama. The northern localities are confined to the Highland Rim Section of the Interior Low Plateau Province, and the southern locality is contained within the Birmingham-Big Canoe District of the Valley and Ridge Province (Sapp and Emplaincourt, 1975). The western limit of the outcrop belt is defined by the Fall Line Hills District of the Eastern Gulf Coastal Plain, which was formed by erosion of the Upper Cretaceous sediments that onlapped the Mississippian and Pennsylvanian strata.

In Alabama, the Highland Rim Section is subdivided according to local relief and bedrock lithology. In Alabama, the Highland Rim is a rolling upland of moderate relief (°250m) that is underlain by carbonate and clastic rocks of Mississippian age. Outcrops of the Mississippian Pride Mountain Formation mostly occur in the Tennessee Valley District of the Highland Rim (Copeland, 1968; Sapp and Emplaincourt, 1975).

To the south of the Highland Rim and separated from it by a 170m high escarpment, is the Cumberland Plateau. This is a dissected region that developed on resistant sandstones of the Pennsylvanian Pottsville Formation.

Along the eastern edge of the Cumberland Plateau are the anticlines and synclines of the Valley and Ridge Province. A single outcrop of Pride Mountain that was used in this study is located northeast of Birmingham in the Birmingham-Big Canoe Valley District of the Valley and Ridge. This district is developed on the Birmingham Anticlinorium and dissects rocks of Cambrian through Mississippian age.

For detailed discussions of physiography refer to Fenneman (1938), Copeland (1968) and Sapp and Emplaincourt (1975).

PREVIOUS STUDY

i. The Black Warrior Basin

The Black Warrior Basin (fig.3) is a triangular region of about 89,600 sq. kms. (Mellen, 1947). The northern border is defined by the Ozark and Nashville domai structures. The southeastern and southwestern boundaries are structurally defined by the Appalachian and Ouachita orogenic fronts, respecti vely.

During the Mississippian, the Black Warrior Basin was a foreland basin that developed on the Alabama Continental Promontory (Thomas, 1977) and contained a mixed si i iciclastic-carbonate shelf and platform. The Chesterian Pride Mountain Formation, together with Floyd Shale and Hartselle Sandstone represents the first of the basin filling sequences. Potential source areas for Mississippian and Pennsylvanian clastic units in the Black Warrior Basin are a matter of continuing debate. Several source areas have been suggested that include both of the adjacent mobile belts (Hobday, 1974; Thomas, 1974; Horsey, 1981; Mack et al., 1981, 1983) as well as the cratonic regions to the north (Swann, 1964; Graham et. al., 1976; Cleaves and Broussard, 1980).

Studies of the Black Warrior Basin therefore, cannot be divorced from the evolution of the adjacent mobile belts and it is important to understand the tectonic origins of the Appalachian and Ouachita mobile belts in order to understand events within the basin. The plate tectonic origins for the mobile belts have been related to island arc and/or continental margin convergences that involved the southeast margin of North America and the northwest margin of Gondwanaland (Wickham et. al., 1976; Thomas and Neathery, 1982; Mack et. al., 1983).

Given the nature and position of the Black Warrior Basin, the study of ostracode faunas within the basin holds much potential for addressing problems of regional palaeogeography.

ii. Stratigraphy

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

i) early Mississippian cherts and carbonates
ii) late Mississippian platformai carbonates and progradational clastic wedges.
iii) Pennsylvanian progradational clastic wedges.

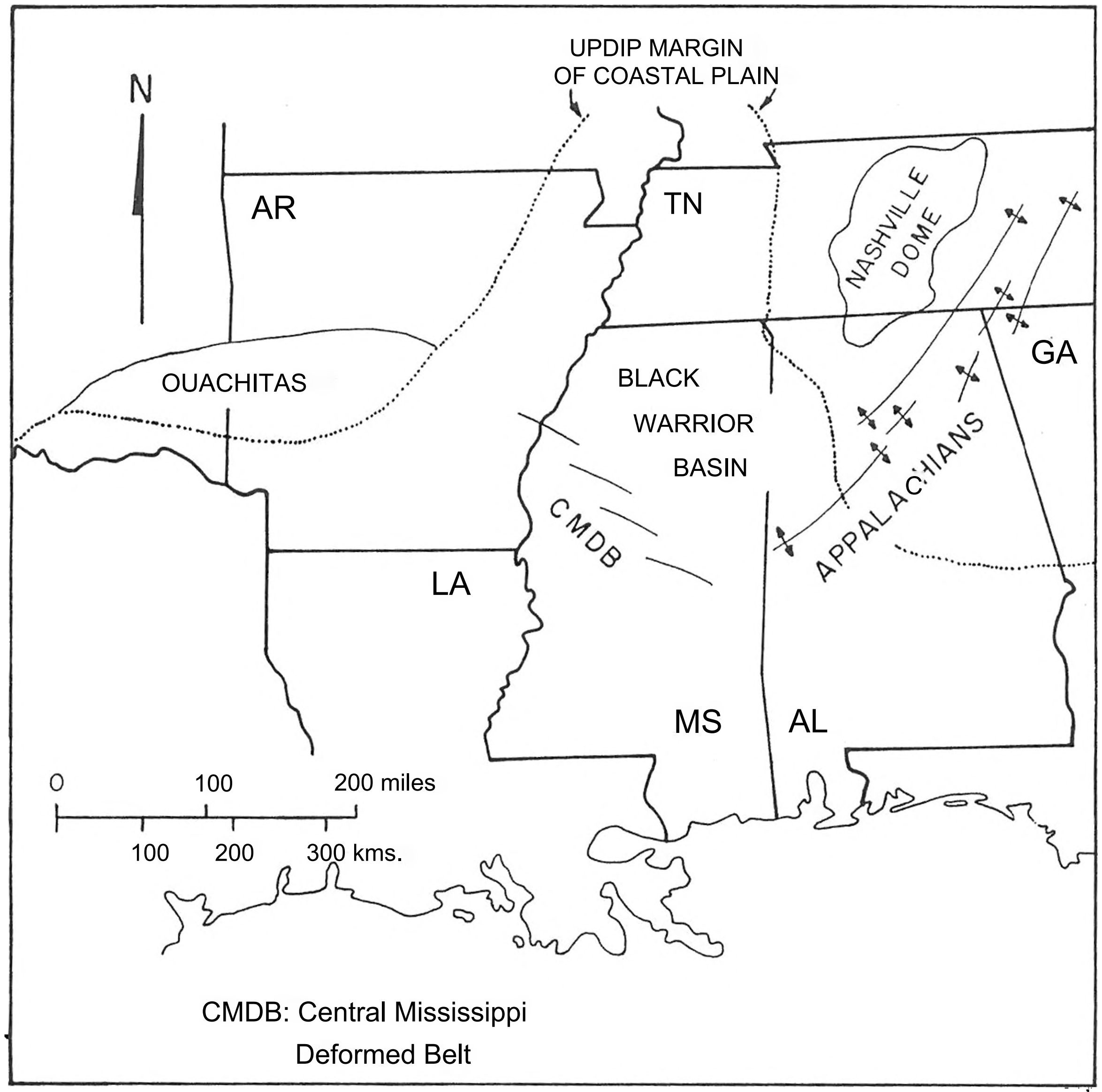


Figure 3: Black Warrior Basin

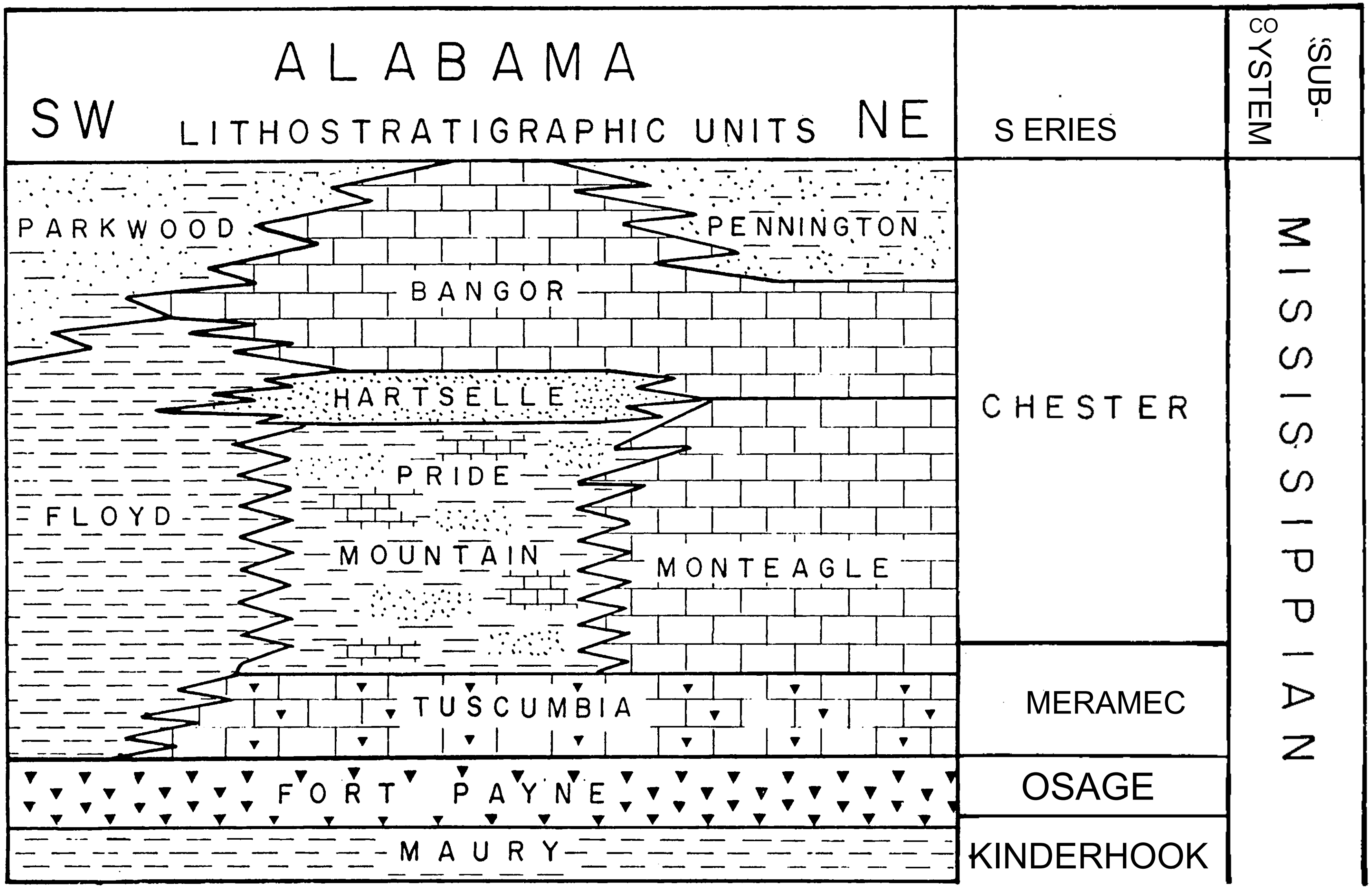


Figure 4: Mississippian Stratigraphy of the Black Warrior Basin

The late Mississippian platformai sequence overlies the Tuscumbia Limestone and is associated with parts of three progradational clastic wedges. The carbonate platform developed primarily in northern Alabama on the East Warrior Platform (Thomas, 1972). The carbonate sequence can be divided into the lower, massive, 65m thick Monteagle Limestone, and the upper, more extensive, 150m thick Bangor Limestone. Both units are composed of bioclastic and oolitic limestones interbedded with calcareous muds. Both units also thin and interfinger with clastic wedges to the west and southwest. The Bangor also interfingers with a clastic wedge to the northeast (fig.4).

The Mississippian strata of the Black Warrior Basin contain three progradational clastic wedges. These are the Floyd-Pride Mountain-Hartselle, the Parkwood and the Pennington. The Floyd-Pride Mountain-Hartselle package is a southwest thickening wedge that extends northeastward, over the western Black Warrior Basin, and interfingers with carbonates of the Monteagle and lower Bangor.It is the first of the basin-filling clastic wedges and is thought to be derived from a southwestern source area (Thomas, 1972).

The Pride Mountain Formation is a mixed carbonate-si i iciclastic unit that was first defined by Welch (1958) in Colbert County, Alabama. For a history of the stratigraphic nomenclature of strata referable to the Pride Mountain see Thomas (1972).

The Pride Mountain can be defined as a variably thick (max 90-130m) series of shales interbedded with thinner units of limestone, sandstone and siltstone (Welch, 1958; Thomas, 1972). The Pride Mountain overlies the Tuscumbia Limestone and is overlain by the Hartselle Sandstone. It is laterally correlable with the Floyd Shale and the Monteagle Limestone (fig.4).

Welch (1958), divided the Pride Mountain into seven members, which he recognised as being of only local extent in Colbert County. Attempts to apply this subdivision beyond the type area clearly demonstrate the extensive lateral variability of the Pride Mountain Formation. The seven members are, in descending order:

Green Hill
Mynot Sandstone
Sandfali
Southward Springs
Wagnon
Tanyard Branch
Al sobrook.

At the base of the Pride Mountain Formation in Colbert County, is a productid-bearing limestone which contains a high abundance of Inflaţia inflatus. This unit is normally less than 10m thick.

In Lawrence, Cullman and Blount Counties, the Pride Mountain contains up to three sandstone units that can be traced to the southwest. Each of the sandstones trend northwest-southeast and pinch out to the northeast and southwest.

The lower sandstone (Thomas, 1972) is interbedded with limestones and shales and is equivalent to the Tanyard Branch Member (Welch, 1958). The middle sandstone (Thomas, 1972) also contains limestone beds, especially in Colbert County, where the middle sandstone is almost entirely represented by limestone facies. The middle sandstone is equivalent to the Southward Springs Member (Welch, 1958). The upper sandstone (Thomas, 1972) is equivalent to the Mynot Sand Member (Welch, 1958) and in Colbert County, northeastward of the clastic limit, it is replaced by a limestone facies. Further to the northeast, in Morgan, Madison and Marshall Counties, the Pride Mountain interfingers with the Monteagle Limestone.

Deposition of the Pride Mountain sandstones has been suggested to have occurred as a series of offshore bars (Thomas, 1972, 1974, 1981). This is based upon a number of criteria which include the northwest-southeast orientation of the sand bodies in Alabama, the enclosure of the sands between clay shales and limestones, the fact that the sands pinch out to the southeast beyond the Birmingham Anticlinorium and the fact that the sands coarsen to the southwest.

More recent work (Holmes, 1981; Di Giovanni, 1984) suggested that the sandstones of the Pride Mountain were deposited as continental shelf-type sand ridges that were reworked by storm activity. The sand ridges are 10‘s kms long, 2-5kms in frequency and 10's ms in amplitude. Holmes (1981) suggested that the Lewis Sandstone (lower Pride Mountain) was produced by storm activity and later reworked by processes similar to those active in the modern environments of the North Sea (sensu Off, 1963) with sand ridges oriented parallel to tidal currents.

Although this is a likely scenario for the sands of the Pride Mountain, the original provenance of the sands remains a matter of debate. Thomas (1972) favours an origin to the southwest and Cleaves and Broussard (1980) favour an origin to the northwest.

iii. 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. became the focus of continued study. At this time two of the most important workers were Coryell and his students (Coryell and coworkers, 1928, 1931, 1932, 1933, 1938, 1939, 1942) and Croneis and his students (Croneis and coworkers, 1938, 1939). The most significant solitary worker for this period was Chalmers B. Cooper who worked with the Illinois Survey (Cooper, 1941, 1946). Since much of the new work that appeared during this time was produced by a number of different authors a problem that has developed in recent years has been one of taxonomic synonymy.

Prior to the beginning of the Black Warrior Research Program at Mississippi State University, only three studies had mentioned ostracodes from the Black Warrior Basin. McGlammery (1955) is a subsurface report which simply mentions the presence of ostracodes at particular horizons. Ehrlich (1964) described a small fauna from a single locality within the Pennington Formation. Mandelbaum (1971) is an unpublished MS thesis which focussed on ostracodes from the Pride Mountain and Monteagle Formations.

The Black Warrior Research Program is intended to produce an extensive series of studies on the ostracodes of the Black Warrior Basin. An abstract (Devery and Dewey, 1986), was a preliminary statement concerning the ostracode fauna from the Bangor Limestone. This statement was followed by the completed thesis (Devery, 1987), which is now awaiting preparation as a manuscript for publication. The study of ostracodes from the Bangor Limestone, produced a very abundant, high diversity, exceptionally preserved fauna that will act as a basis for further study in the basin. The Bangor fauna is typically mid-continental in aspect and was used to delineate a number of biofacies within the Bangor that could be related to palaeoenvironmental conditions.

METHODOLOGY

i. Field Methods

Field studies in the Pride Mountain were conducted in Colbert, Lawrence and Jefferson Counties. The established literature was used as an initial data base for outcrop location. Outcrops were investigated from Welch (1959), Smith (1967), Mandelbaum (1971), Thomas (1972), Burdick and Strimple (1982) and Di Giovanni (1984).

One of the main problems in studying the Pride Mountain was the poor quality of many of the outcrops. The type locality is almost completely overgrown and many of the established outcrops have been lost due to weathering.

A series of 7.5 minute USGS and TVA topographic quadrangle maps were used to locate and map outcrops. After reconnaissance, field locations were chosen that reflected the main aims of the research. Proximity to a distinct stratigraphic horizon such as the Productid Bed or the base of the Hartselle was an important criterion for chosing outcrops, because such markers provide valuable stratigraphic controls for correlation. Due to the lateral variability of the Pride Mountain, short vertical outcrops that could not be referenced to a distinct iithostrati graphic horizon, were not use in this study.

Measured sections were constructed using standard procedures with a Brunton compass, tape, hand level and three metre staff.

The sampling net was determined by lithology, macrofossil content and vertical thickness of the unit. To prevent time averaging and multi-environment sampling, samples were collected from the narrowest possible vertical thickness. Sample size averaged 2-3kg.

i i. <u>Laboratory Methods</u>

Samples were processed using the same methods described in Dewey (1986). The samples were macerated and oven dried, then simmered in Calgon and water, then wet sieved and oven dried. Samples that would not disaggregate using Calgon alone were treated with 15% Hydrogen Peroxide.

Ostracodes were picked under a Bausch and Lomb stereo microscope from a three-quarter split of the 125 m and 250 m fraction and the full sample of 500 m, 800 m and 1.0mm size fractions. If ostracodes were not found after picking 10 trays of each of the 250 m and 500 m fractions, the sample was considered barren. Individual ostracodes were cleaned using an ultrasonicator.

Taxonomic details were studied using an HHS-2R Scanning Electron Microscope with a Polaroid Camera attachment.

RESULTS

i. Measured Sections

Ostracodes were described from twelve measured sections of the Pride Mountain Formation in Colbert, Lawrence and Jefferson Counties, Alabama. Picked residues were also examined from three wells in Itawamba County, Mississippi and Colbert County, Alabama.

The intention of the study was to collect ostracodes from a variety of lithologies, and use them to provide a palaeoenvironmental interpretation of the Pride Mountain Formation. The ostracode fauna of the Pride Mountain, combined with that of the Bangor will help to build the data base from which a biostratigraphic framework for the Black Warrior Basin can be determined.

In total, over 200m of section were measured and 46 samples collected. Most of the sections are easily accessible along road cuts or in quarry workings. One outcrop, Black Wax Hill, was destroyed during the course of study due to road construction.

The detailed examination of the sections and their ostracode content forms part of an ongoing MS thesis here at M.S.U..

The measured sections (M) and borehole data (B) were located as follows:

Itawamba County, Mississippi

	Greggtex Gasoline Corp. No.1 Burdine.
B	NW 1/4 NE 1/4 SE 1/4, Sec.16, T.II.S, R.9.E.,
	Turon Quad.
	Grasty #1 Kentucky Lumber Co.
B	Sec.7, T.10.S, R.10.E, Tremont Quad.

Colbert County, Alabama

	Mellen and Gear #1 Alsobrook
B	S 1/2 SW 1/4 NW 1/4, Sec.10, T.4.S, R.15.W,
	Bishop Quad.
	Pennywinkle Creek I (fig.5)
M	Sec.4, T.4.S, R.15.W, Bishop Quad
	Pennywinkle Creek II (fig.6)
M	S 1/2, Sec.34, T.3.S, R.15.W, Margerum Quad

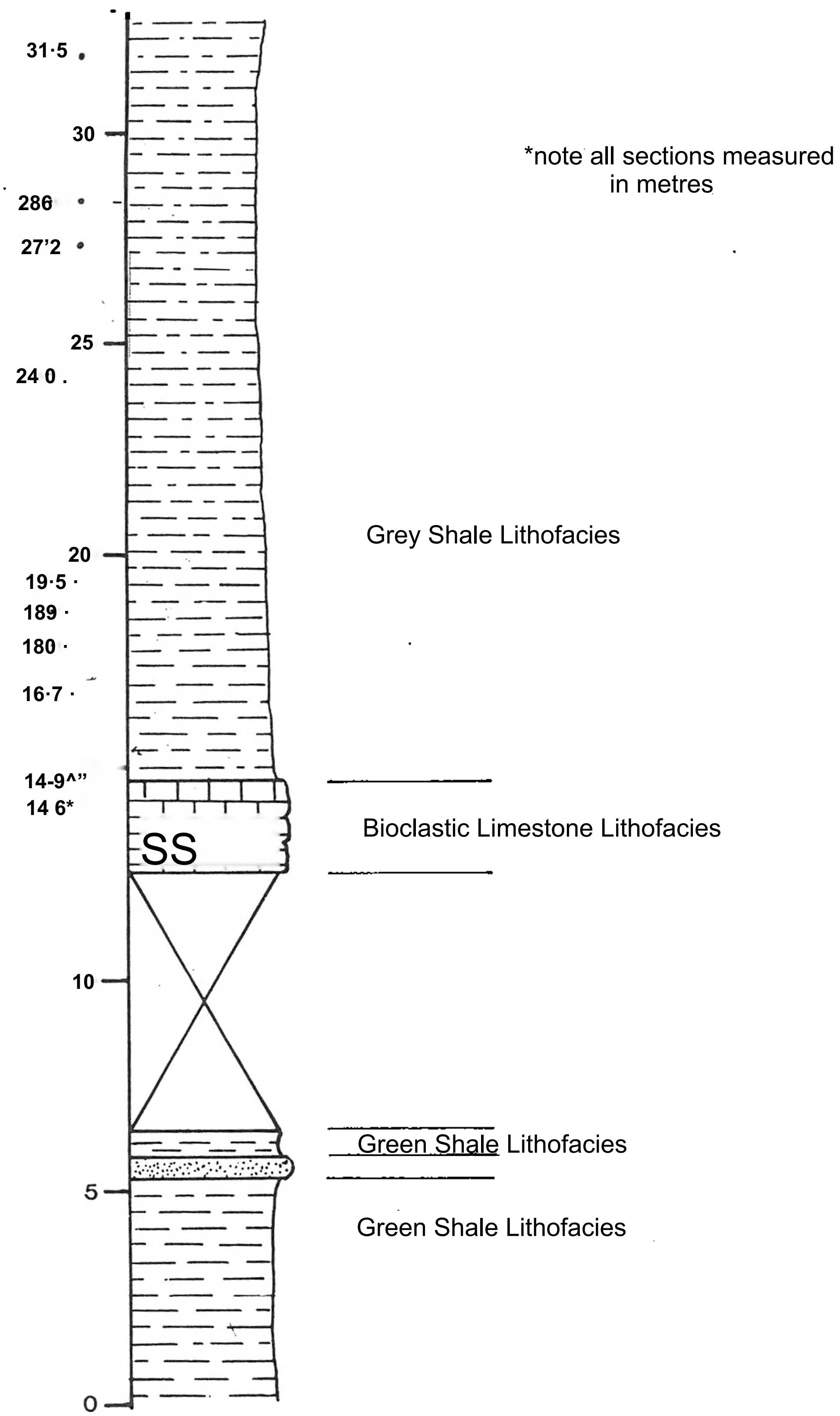


Figure 5: Pennywinkle Creek I Section

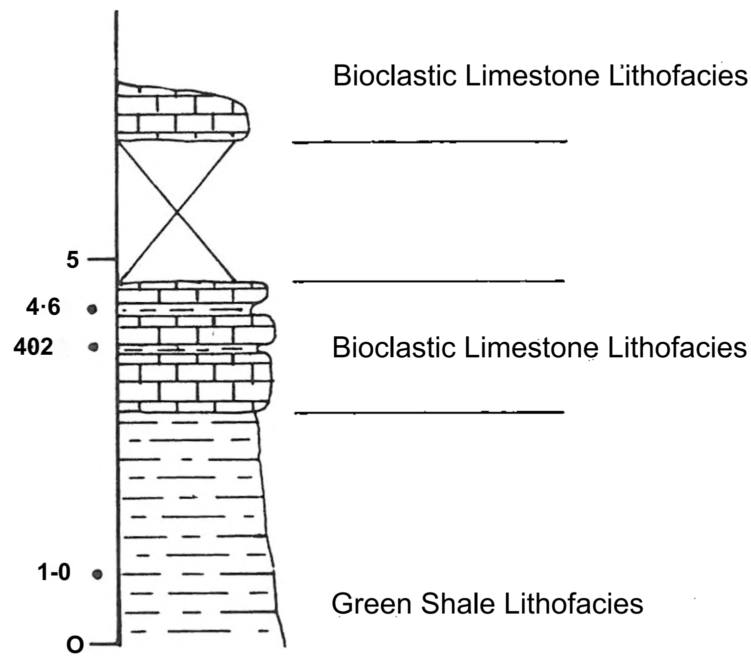


Figure 6: Pennywinkle Creek II Section

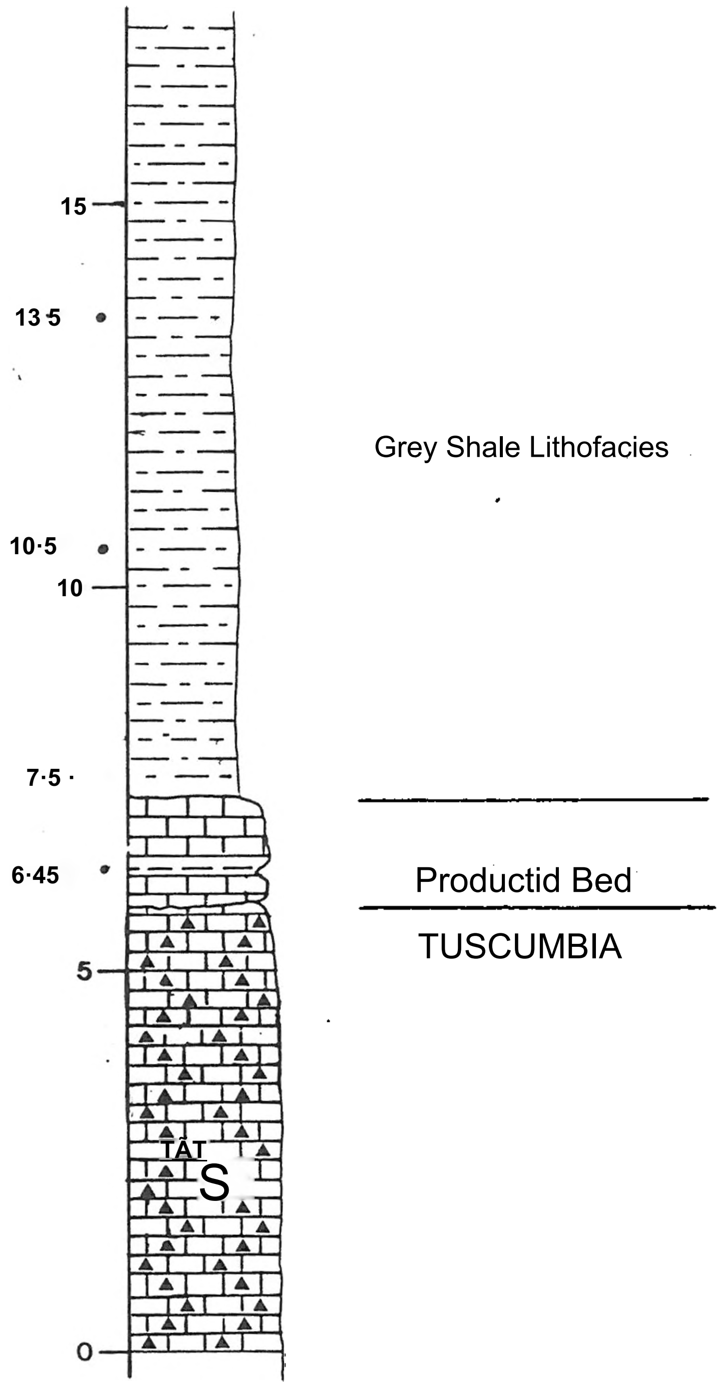


Figure 7: Lime Kiln Hollow Section

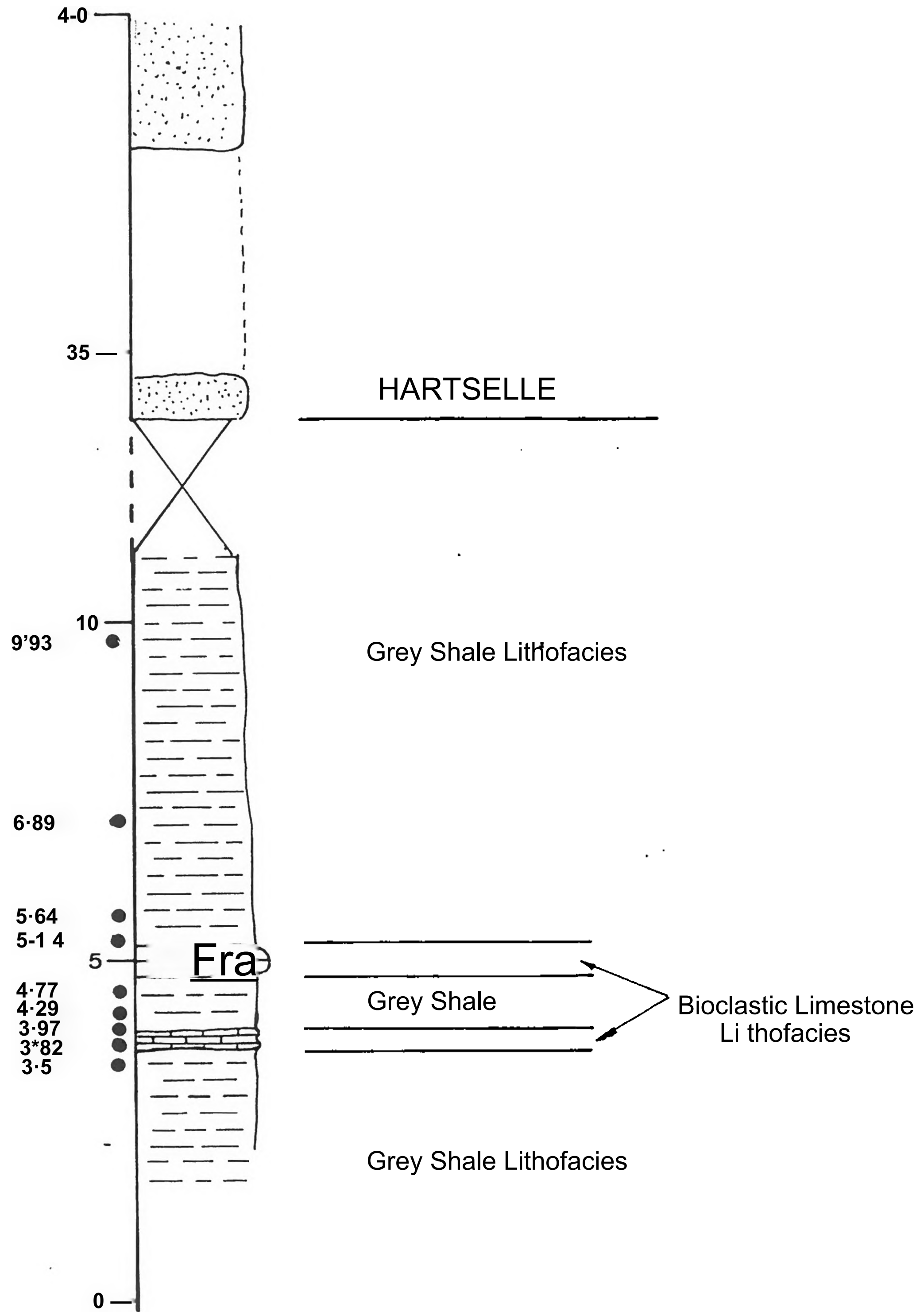


Figure 8: Williams Spring Section

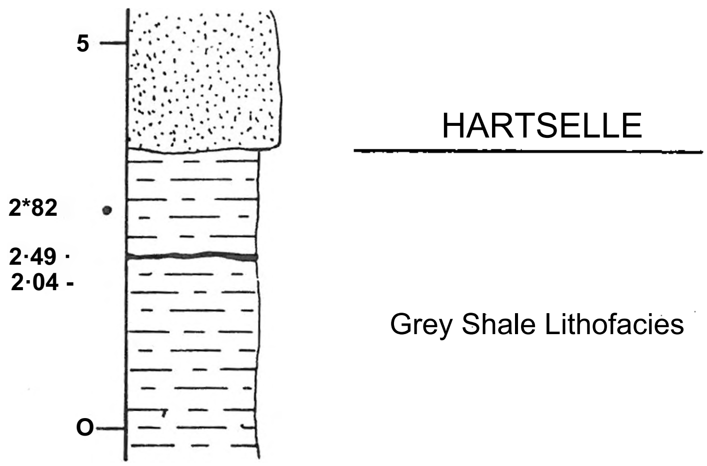


Figure 9: Fielder Ridge

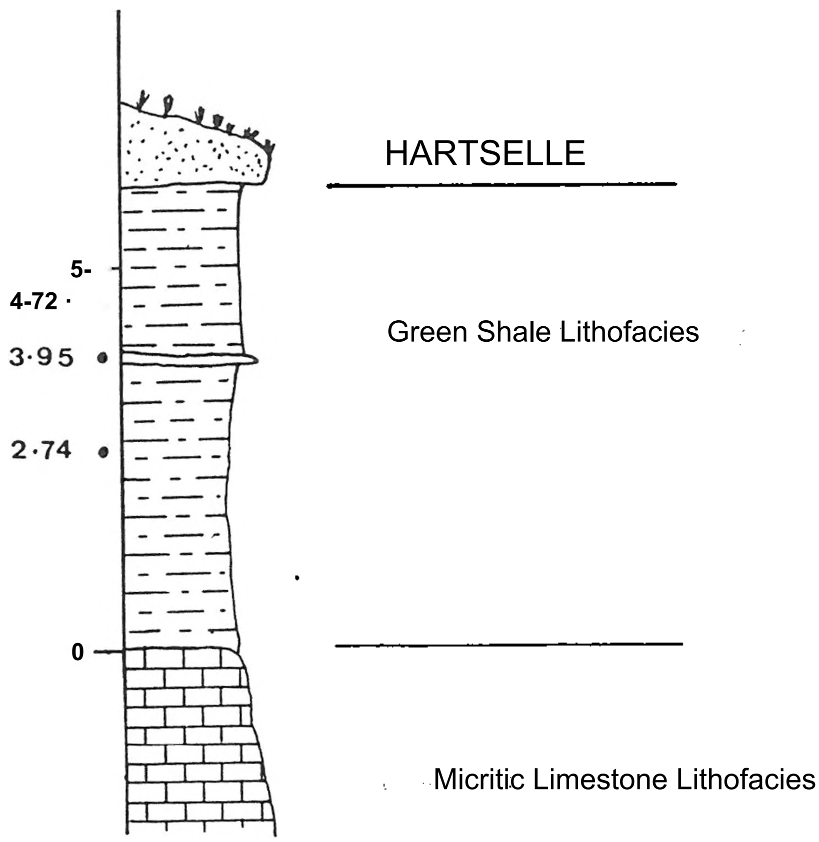


Figure 10: Henson Creek

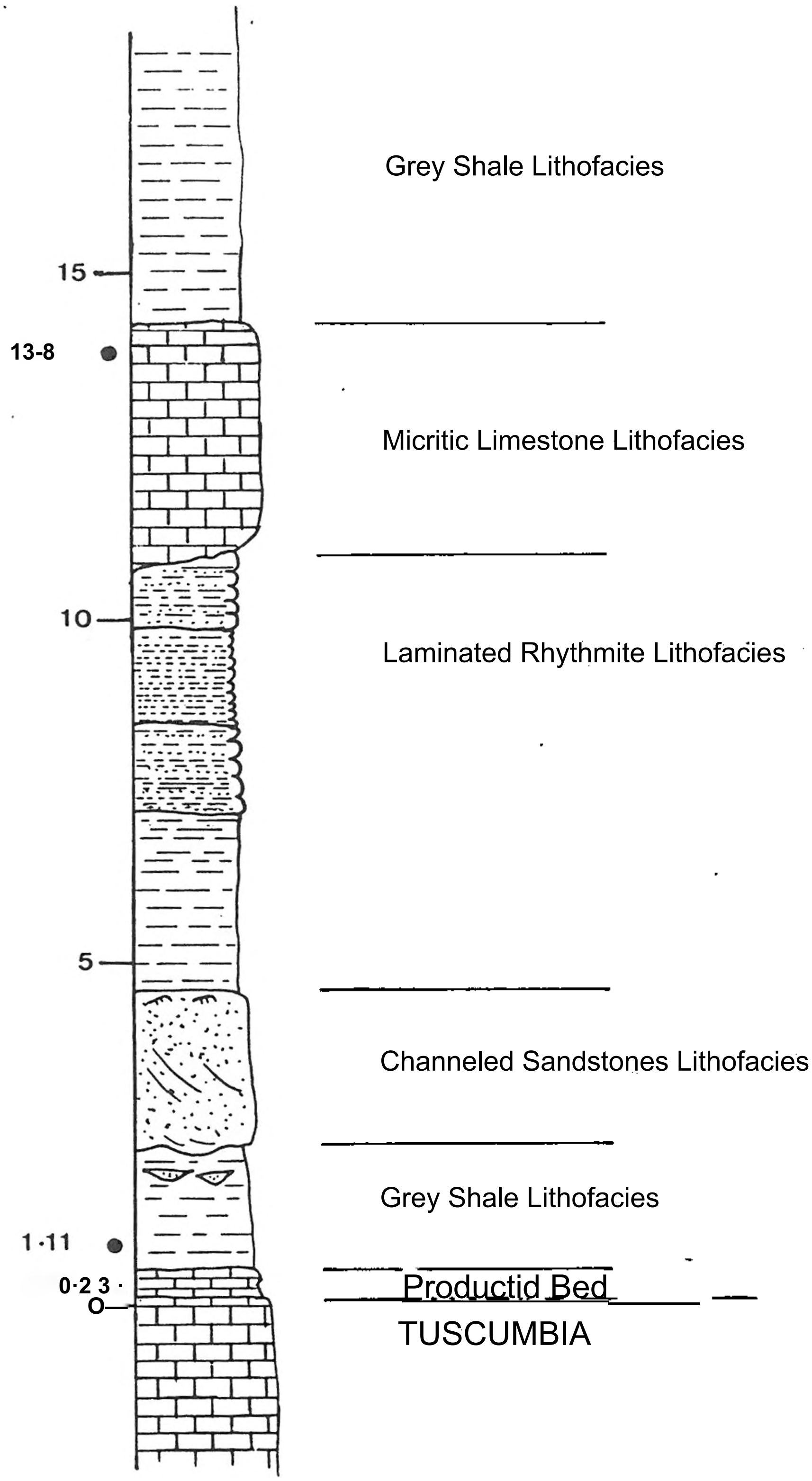


Figure 11: Vulcan Materials Quarry Section

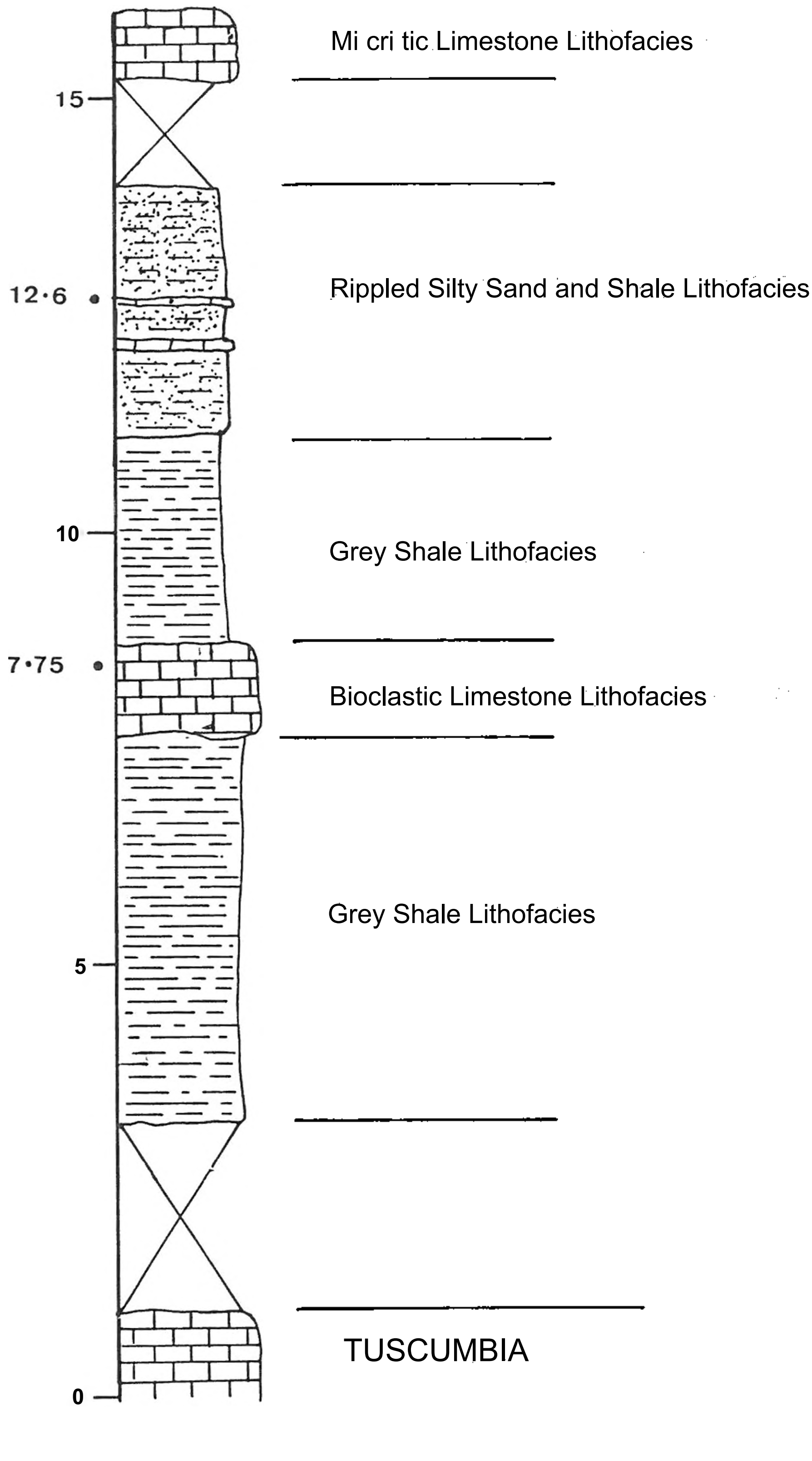


Figure 12: Bald Knob Section

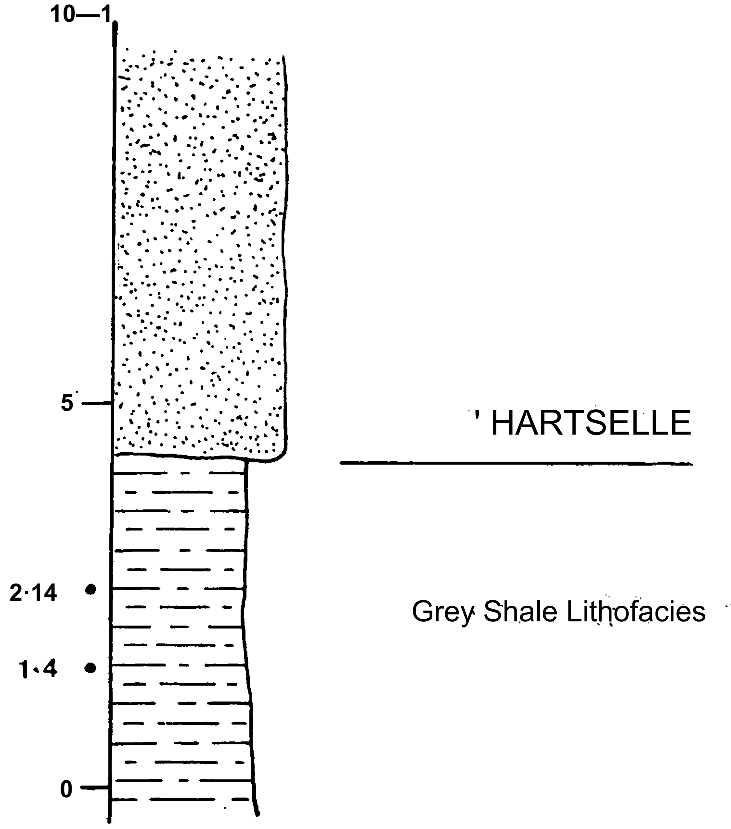


Figure 13: Black Wax Hill

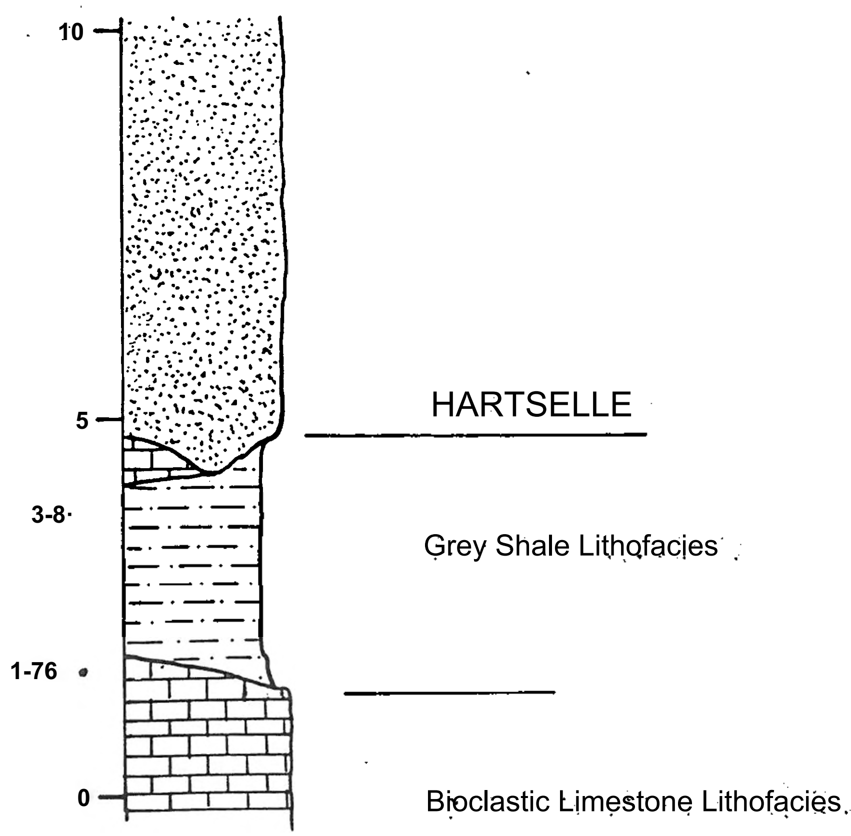


Figure 14: Crooked Creek

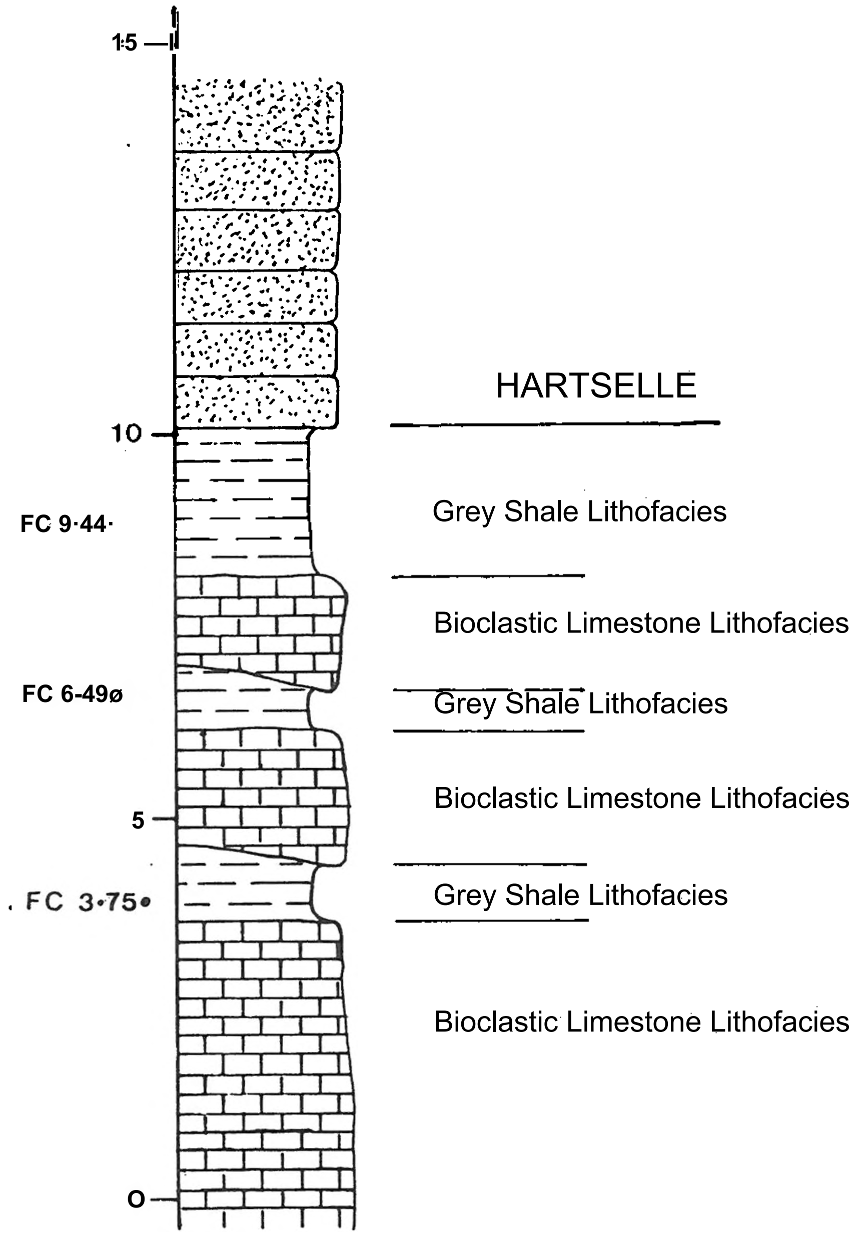


Figure 15: Fellowship Church Section

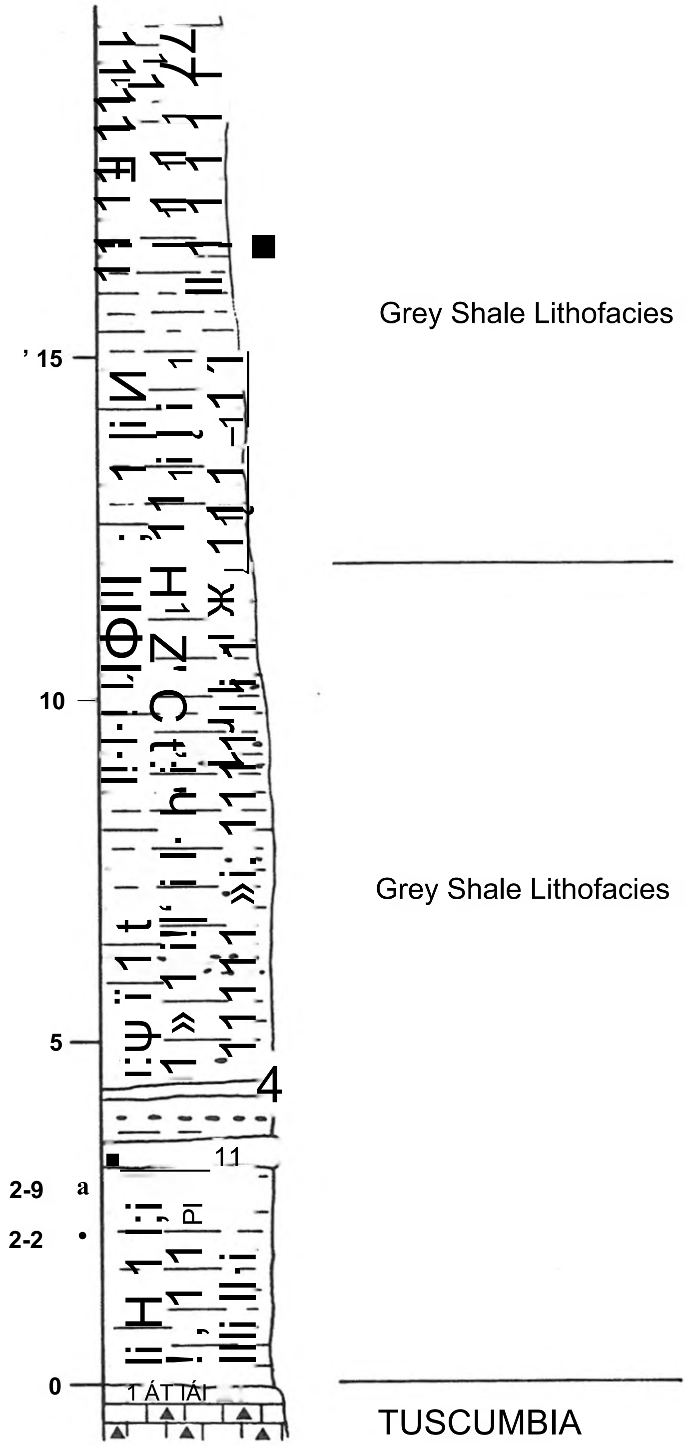


Figure 16: Dry Creek Quarry Section

Lime Kiln Hollow (fig.7)
M NW 1/4, Sec.31, T.3.S, R.14.W, Margerum Quad

Williams Spring (fig.8)
M SE 1/4, Sec.34, T.4.S, R.14.W, Barton Quad

Fielder Ridge (fig.9)
M S 1/2, Sec.3, T.5.S, R.13.W, Barton Quad

Henson Creek (fig.10)
M E 1/2, Sec.35, T.4.S, R.13.W, Barton Quad

Vulcan Materials Quarry (fig.11)
M SW 1/4, Sec.18, T.4.S, R.II.W, Tuscumbia Quad

Bald Knob (fig.12)
M W 1/2, Sec.19, T.4.S, R.II.W, Tuscumbia Quad

Lawrence County, Alabama

Black Wax Hill (fig.13)
M C Sec.15, T.5.S, R.9.W, Hatton Quad

Crooked Creek (fig.14)
M S 1/2, Sec.21, T.5.S, R.8.W, Hatton Quad

Fellowship Church (fig.15)
M N 1/2, Sec.36, T.5.S, R.6.W, Trinity Quad

Jefferson County, Alabama

Dry Creek Quarry (fig.16)
M SW 1/4 NE1/4, Sec.14, T.16.S, R.I.W, Argo Quad

ii. Lithofacies

a) Grey Shale Lithofacies

This lithofacies is composed of fissile, buff weathering, pale to dark grey shales. The lithofacies often contains impersistent bioclastic grainstone to wackestone horizons (e.g. Fielder Ridge). Elsewhere, such as at Dry Creek Quarry and Pennywinkle Creek I, siderite horizons are common. Fossil content within the shales is variable. At Dry Creek Quarry, the lower parts of the grey shale sequence contain gastropods, trilobites, bryozoans, goniotites, brachiopods and bivalves; however the upper part of the sequence only contains a sparee bivalve fauna. Sparcely fossi 1iferous grey shales are normally slightly siltier and show an increase in mica and plant debris content.

Locations: Pennywinkle Creek I, Lime Kiln Hollow, Fielder Ridge, William Spring, Vulcan Materials Quarry, Black Wax Hill, Fellowship Church, Dry Creek Quarry and Bald Knob.

b) Green Shale Lithofacies

The green shale lithofacies is composed of thinly bedded, fissile, buff to green weathering shales. The shales often contain thin calcareous partings, but are generally non-fossiliferous. At Henson Creek, the green shales contain a thin crinoid-bryozoan-brachiopod horizon.

Locations: Henson Creek, Pennywinkle Creek II.

c) Productid Limestone Lithofacies

This lithofacies is a distinctive unit that occurs at the base of the Pride Mountain in Colbert County. The lithology is a recrystal 1ised, fine grained, grey argillaceous limestone with thin, buff to green weathering shale horizons. The limestone is distinctive for the abundance of the productid brachiopod Inflati a i nf iatus.

Locations: Vulcan Materials Quarry and Lime Kiln Hollow.

d) Micritic Limestone Lithofacies

The micritic limestone lithofacies is about 2m thick and composed of massive, grey, layered micrites. The layering contains thin, (less than 10cm thick) bioclastic packstones; thin, (less than 10cm thick) orange weathering, crinoid-bryozoan rich pack- to wackestones and thick (10's cm thick), massively bedded, wackestones. The thick, massive wackestones are vuggy and contain irregular patches of grainstone. The layering within this lithofacies is repeated several times, but is not rhythmic. Individual layers often exhibit undulóse boundaries with adjacent layers.

At Vulcan Materials Quarry, the upper portions of the lithofacies are planar bedded whereas the lowermost units exhibit low angle cross bedding.

Localities: Vulcan Materials Quarry, Henson Creek and Bald Knob.

e) Bioclastic Limestone Facies

This lithofacies is composed of 2-5m thick, buff weathering, platey, grey packstones. At Fellowship Church the lithofacies shows channelling at the base and is internally cross bedded. The main bioclastic components include pelmatozoan debris, fenestrate and non-fenestrate bryozoans and brachiopods. The packstones often contain thin shaley partings.

Locations: Fellowship Church, Bald Knob, Crooked Creek, Williams Spring, Pennywinkle Creek I and II.

f) Rippled Silty Sand and Shale Lithofacies

This 3m thick lithofacies is a pale buff to brown, thinly bedded rippled siltstone with shale layers. The shale layers often contain starved silty sandstone ripples. The lithofacies contains mica and common plant debris as well as extensive surface trace fossils.

Locations: Bald Knob.

g) Channeled Sandstones Lithofacies

This 2m thick lithofacies consists of buff to dark grey coloured, medium to fine grained, impure, quartzose sandstones. The lithofacies exhibits trough cross bedding and has a channeled base. The lithofacies fines upward and has near symmetrical, straight crested ripples on the upper surface. The sandstone is asphaltic.

Locations: Vulcan Materials Quarry

h) Laminated Rhythmite Lithofacies

The 3m thick, laminated rhythmites can be divided into three distinct packages of roughly equal thickness. Each package contains a series of fining upwards couplets that grade from silty shales to shales. The lowest package contains 2cm thick couplets that get thinner upward. The middle package contains more than 20 very finely grouped couplets and the upper package contains 1-1 l/2cm thick couplets.

Locations: Vulcan Materials Quarry

iii. Depositional Environments

The vertical and lateral variations in lithology, combined with poor outcrop preservation, make it difficult to evaluate the depositional environments of the Pride Mountain.

The most common lithofacies is the Grey Shale Lithofacies. The depositional environment suggested for this lithofacies is a prodeltaic extension of the Floyd Shale. In several cases (Dry Creek Quarry, Pennywinkle Creek I) the shales pass upward from sideritic, fossi iiferous shales into sparcely fossi 1iferous, mica and plant debris-bearing siltier shales. This vertical change suggests a shallowing upward sequence.

A variety of limestone sequences occur within the Pride Mountain. Transported bioclastic packstones with cross bedding and chanelled bases occur at Fellowship Church. The micritic limestones that occur at Vulcan Materials Quarry however, indicate continued, possibly cyclic carbonate production. The development of carbonate lithologies indicate interruptions in clastic input and/or transgressive episodes. In general, the occurrence of carbonates increases in Colbert County, Alabama and northeastward toward the Monteagle carbonate platform.

The crossbedded sandstones have been interpreted as shelf sands (Thomas, 1972, 1974, 1981) or reworked sands associated with storm activity (Holmes, 1981; Di Giovanni, 1984).

The depositional setting for the Pride Mountain can be envisaged as a highly variable mixed si i iciclastic and carbonate shelf. Fine clastic influx was probably associated with progradation of the Floyd Shale, and sand deposition was probably associated with storm activity and shelf tidal currents. During transgressions or interruptions in the supply of terrigenous material, carbonate depositional processes became effective.

Outcrops of the Pride Mountain Formation in northern Alabama, therefore represent a complex series of shelf related sedimentary environments. These environments reflect the combined interactions of the Floyd Shale depositional system from the southwest with the Monteagle carbonate platform to the northeast.

iv. Ostracode Biofacies

Fourty-six samples were processed for ostracodes from the Pride Mountain Formation, of which 12 were barren. A variably abundant, typically mid-continent fauna was described (cf. Cooper, 1941; Devery, 1987) from the remaining samples. The preservation of material ranges from excellent to poor.

Taxonomic details for the fauna have been resolved to the generic level, however taxonomic work is continuing as part of an MS theis at M.S.U.. The taxonomy of Carboniferous ostracodes is in need of revision as demonstrated by the work of Sohn (1960, 1961, 1971); Bless and Jordan (1971, 1972) and the comments of Melnyk (1985). At this stage in the Black Warrior Research Program, the most important aspect is to develop an internally consistent taxonomy. It is important to recognise long ranging, facies dependent species that can be used for palaeoenvironmental analysis and short ranging, facies independent species for biostratigraphic work, within the basin. Detailed taxonomic work that compares faunas from the Black Warrior Basin with type material from other areas forms part of a long term program goal.

Ostracodes from the Pride Mountain may be divided into major taxonomic groupings as follows:

Hollinomorph palaeocopes: Tetrasacculus and Hollinella.
Binodicope palaeocopes: Mammoides and Cornigella
Kirkbyacean palaeocopes: Kirkbya, Polytylites, Amphissites, Reviya, ?Kegelites. Moorites.
Bairdiacean podocopes: Bairdia, Bairdiolites, Orthobairdia, Rectobairdia, Aeratia.
Paraparchitacean podocopes: Chámishaella and Shishaella.
Cytheracean podocopes: Monoceratina.
Healdiacean metacopes: Healdia, Seminolites, Cribroconcha

Quasi 11 itacean metacopes: Euglyphel1 a and Graphiadactyllis.

(Cytherel lacean platycopes: Cavei 1 ina.

Kloedenellocopes: Oliganisus, Sansabel la, Geffeni na, Nufferella, Glyptopleurina, Glyptopleura, Beyrichiopsis, Knoxiella.

Ostracodes of uncertain affinity: Si 1 enites, Pseudobythocypris, ?Evlanovia, ?Chesterella.

The size range of ostracodes from the Pride Mountain, falls mostly within the 0.5-1.Omm fractions. This supports the concept that late Palaeozoic ostracodes from shale-dominated sequences are generally smaller on average than those from carbonate-dominated sequences (Bless et. al. 1981).

In a study of ostracodes from the Bangor Limestone, Dewey (1986) and Devery (1987) related ostracode biofacies to an onshore offshore gradient insofar as it applied to the interaction of the prograding Floyd clastic wedge and the carbonate platform of the Bangor, in northwestern Alabama.

Ostracode assemblages were defined using bairdiaceans as offshore indicators and kloedenel iaceans as nearshore indicators (sensu Bless, 1983; fig.17). Two assemblages, one subassemblage and two informally recognised subgroups were defined (Devery, 1987):

The Bai rdia gol condensi s Assemblage occurred in a calcareous mudstone lithofacies, was associated with shallow offshore conditions and contained two subgroups. The bairdiacean-kirkbyacean-kloedenel lacdan subgroup exhibited the highest abundances and diversity of any ostracode fauna from the Bangor. The bairdiacean-Glyptopleura subgroup was interpreted as representing a mix of the offshore and the nearshore faunas.

The Sansabell a Assemblage mostly occurred within interbedded mudstone and limestone lithofacies and was the most common ostracode biofacies from the Bangor. It was interpreted as a nearshore, low diversity, high abundance fauna from a stressed environment. The Kirkbyel1 a gutkei Subassemblage was very similar to the Sansabella Assemblage but contained a larger diversity of kirkbyaceans, cavel linids and healdiaceans. This subassemblage was interpreted to occur in more variable, muddy, nearshore conditions than the Sansabella Assemblage sensu stricto.

The main controlling factors for distribution of ostracodes in the Bangor were suggested to be salinity and influx of terrigenous material (Devery, 1987). It is important to realise however, that occurrence of so-called nearshore faunas may not be simply a function of depth

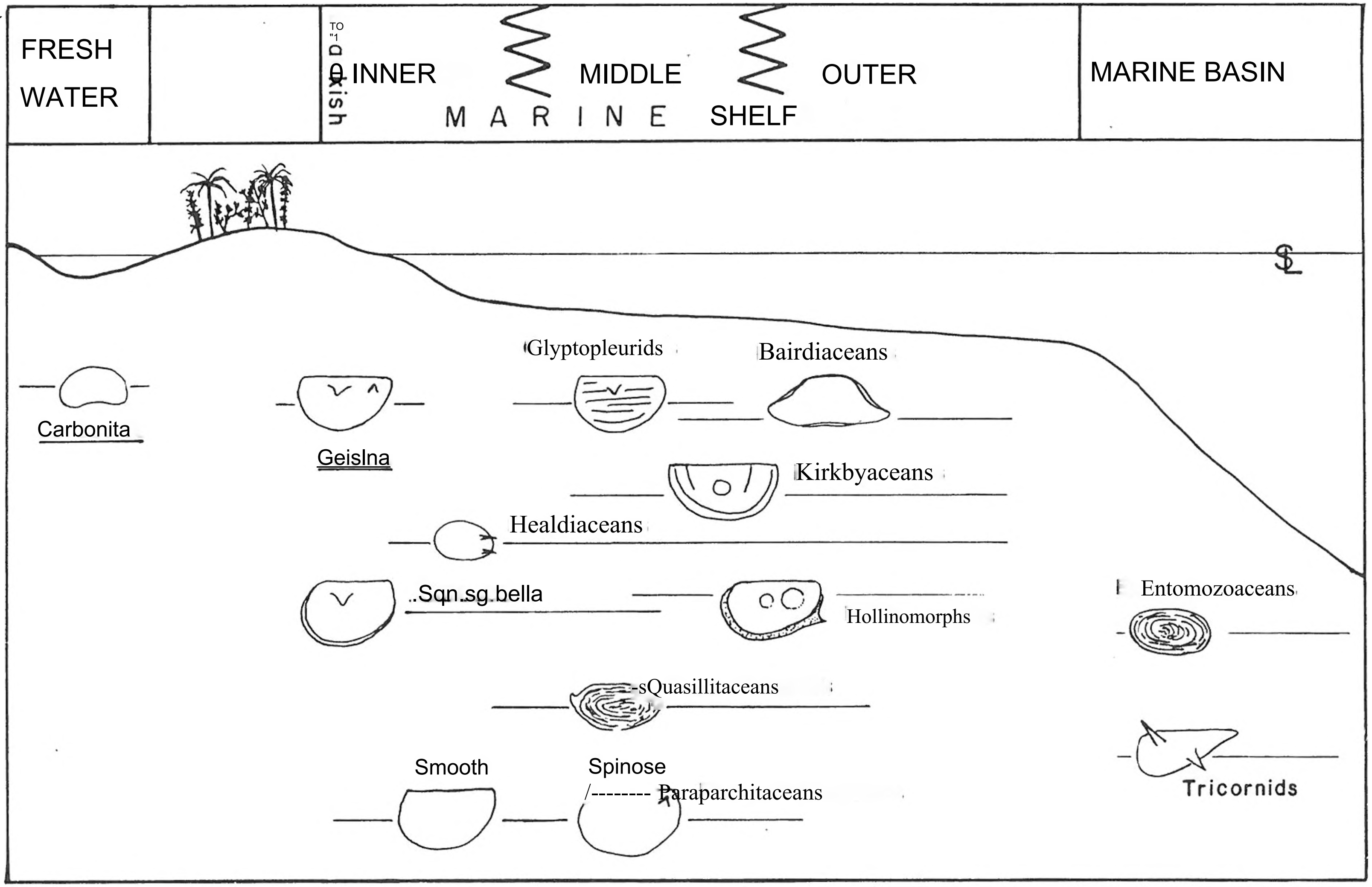


Figure 17: Environmental Index of Carboniferous Ostracodes (modified from Bless, 1983).

and/or distance from shore so much as the nature of prevailing environmental conditions.

The ostracode distribution patterns seen in the Bangor, are to some extent repeated in the Pride Mountain samples, however there are distinct differences. The main ostracode assemblages in the Pride Mountain are:

i) A bairdiacean assemblage
ii) A quasi 11itacean-Amphissites-binodicope assemblage
iii) A kloedenellacean assemblage.

Ostracode assemblages for the Pride Mountain are defined by the numerically dominant genera present in each sample. Each assemblage represents a recurring association of genera. The faunas from some samples are referred to as mixed assemblages (Table 1); in such cases the assemblage also contains some indicators from another assemblage. At this stage in the research Table 1 is intended to be a guide to understanding the distribution of assemblages within the measured sections. The quantitative work necessary to substantiate these assemblages is still being completed as part of an MS thesis here at M.S.U..

The bairdiacean fauna is characteri sed by a high diversity and abundance of bairdiaceans, although they are not as diverse as the Bai rdia gol condensi s Assemblage (Devery, 1987). The assemblage is associated with hollinomorphs and kirkbyaceans. Polytylites is the most common kirkbyacean in this assemblage. Kloedenellaceans are scarce. The assemblage occurs only in the Micritic Limestone Lithofacies (Vulcan Materials Quarry). It is interpreted to represent shallow offshore, clear water conditions.

The quasi 11itacean-Amphissites-binodi cope assemblage is found in green and grey shales and the thin limestones that occur within these lithofacies. It is found at Henson Creek, Fielder Ridge, Fellowship Church, Williams Spring and Dry Creek Quarry. A mixed fauna of quasi 11itaceans and bairdiaceans occurs at Fielder Ridge (sample FR 2.49), in a thin bioclastic calcareous shale.

The quasi 11itacean-Amphissites-binodi cope assemblage has no analogue in the assemblages described for the Bangor (Dewey, 1986, Devery, 1987). The assemblage does however, relate to parts of type 2 & type 3 assemblages of Mandelbaum (1971). Mandelbaum (1971) indicates that the Polytylites common in type 1 assemblages are mutually exclusive to the quasi 11itaceans and kloedenel1aceans of type 3 assemblages. This relationship is true for the present study, except where the fauna also contains bairdiaceans (e.g. FR 2.49 & WS 4.29).

Sample #	Bai rdiacean Assemblage	Quasil1itid- Amphi ssi tes Bi nodi cope Assemblage	Kloedenellacean Assemblage
BK 7.75			A
11.6			A
BWH 1.4			A
2.15			A
CC 1.76			A
3.8			A
DCQ 2.2			A
2.9		*	
FC 3.75		*	
6.49	x		*M
FR 2.04		*	
2.49	x	*M	
2.82		*	
HC 3.95		*	
LKH 6.49			A
10.5			A
13.05	*?.		
PCI 14.6	x	x	*M
14.9			A
16.7			A
18.0			A
27.2			A
PCII 4.6	x		*M
VMQ 13.6	*		
WS 3.55			A
3.82			A
3.97			A
4.29	x	*M	
4.77		*	
5.14			A
5.64		*	
6.89			A
9.93	x		*M

Table 1 Distribution of ostracode assemblages

Key: *M mixed assemblage
x assemblage indicators in *M assemblages

For location abbreviations see fig.2
Note: samples not listed were barren

The samples from the Bangor represent a predomi nantly carbonate environment subject to the influx of fine grained terrigenous material from the distal end of the Floyd clastic wedge (Devery, 1987). The samples from the Pride Mountain, by contrast, represent predominantly si iiciclastic environments characterised by large volumes of fine terrigenous material and relatively short-lived carbonate and/or sandy depositional events.

In summary, ostracode distributions from the lower Bangor represent the effects of fine grained terrigenous input on a carbonate platform, whereas those from the Pride Mountain reflect short lived carbonate events on a si 1iciclastic shelf.

v. Subsurface Results

Picked residues from intervals of three boreholes were also provided for study by Mr. Fred Mellen. Ostracodes were noted from a number of different horizons, however none of these coincided with the Pride Mountain stratigraphic interval. Preservation of ostracode material from the borehole samples was very good.

In all but one horizon (Grasty #1) the ostracodes are indicative of open shelf bairdiacean assemblages:

Greggtex Gasoline Corp No.1 Burdine
a) 675-80' pale buff micrite,
Parkwood Formation.
Glyptopleura, Bairdia, Cavei iina and
Sansabella
b) 905-10' grey argillaceous limestone
Mil 1 erei la Limestone (top of Bangor)
Cavell ina, Glyptopleura, Glyptopleuroi des
c) 1155-66'dark grey silty shale
Bangor Limestone
Paracavellina, Bai rdi a, Heal dia

Grasty #1 Kentucky Lumber Co.
a) 710-20' grey argillaceous limestone
Bangor Limestone
Sansabella, Knoxiella

Mellen and Gear #1 Alsobrook
a) 14-18' buff limestone
Tuscumbia Limestone
Bai rdia, Bairdiacypris, Aerati a,
Glyptopleura, Heal di a, Cavei lina, 01iganisus

As the Black Warrior Reseach Program develops, more subsurface work will be added to augment the outcrop study. In this way it will be possible to relate the palaeoenvironmental and biostratigraphic data to the search for hydrocarbon reserves in the Black Warrior Basin.

SUMMARY AND CONCLUSIONS

The data accrued thusfar in the study of ostracodes from the Black Warrior Basin have been used primarily to build a palaeoenvironmental framework. Continuing work will begin to evaluate the detailed taxonomy and the biostratigraphic utility of the fauna.

The results of this study, combined with those from the previous MMRI study (Dewey, 1986; Devery 1987) can be expressed in a series of ternary diagrams (fig.18). The diagrams are developed by using ratios of Bairdiaceans plus Palaeocopes : Kloedenel laceans : Other.

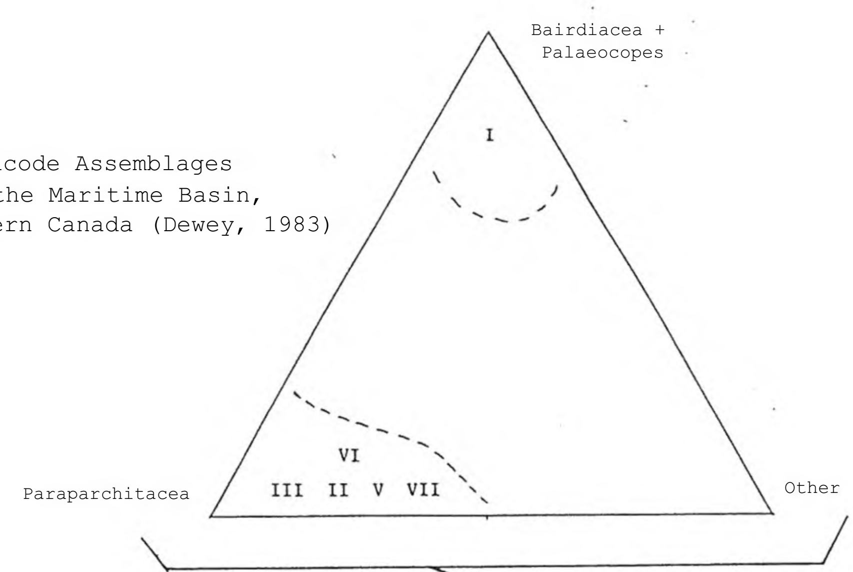
Modern bairdiaceans are thought to be stenohaline organisms, indicative of tropical and subtropical clastic and carbonate environments of near normal marine salinity (35ppt) (Kornicker, 1961; Maddocks, 1969). Late Palaeozoic bairdiaceans also seem to be indicative of stable clastic and carbonate offshore conditions (Bassler & Kellett, 1934; Sohn, 1961; Bless, 1983).

In the Black Warrior Basin, faunas that exhibit a high abundance and diversity of bairdiaceans are only found in the most stable offshore carbonate environments. Their lack of occurrence in clastic shelf environments of the Pride Mounain may be a salinity controlled phenomenon, associated with the effects of progradation of the Floyd.

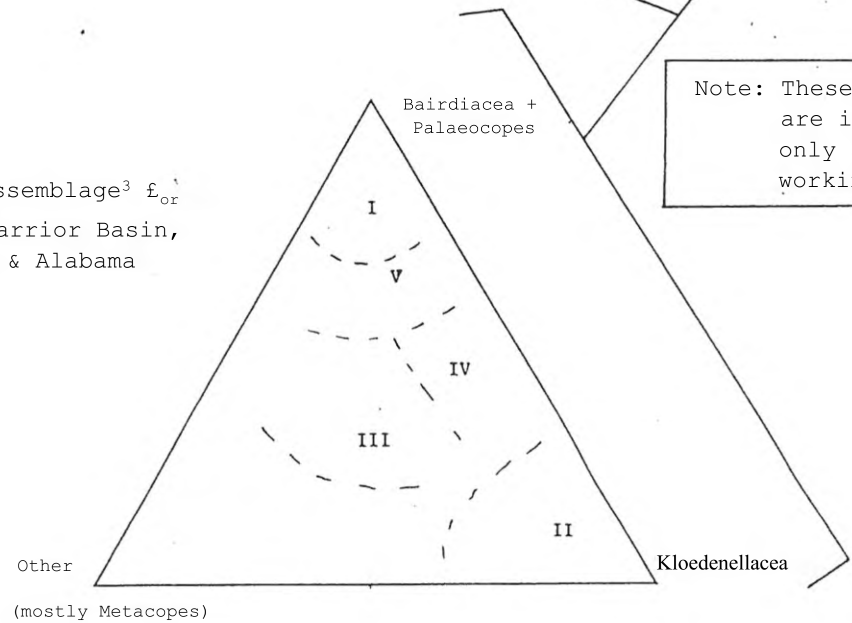
Kloedenellaceans have no modern analogues, however their lithological and macrofaunal associations indicate that most kloedenellaceans are best suited to nearshore conditions (Bless, 1983). Sansabella and Gei si na are indicative of the most nearshore conditions and the glyptopleurids seem to favour environments further from shore. Crasquin (1984) considers that kloedenel1acean-dominated faunas are related to restricted or confined envi ronments.

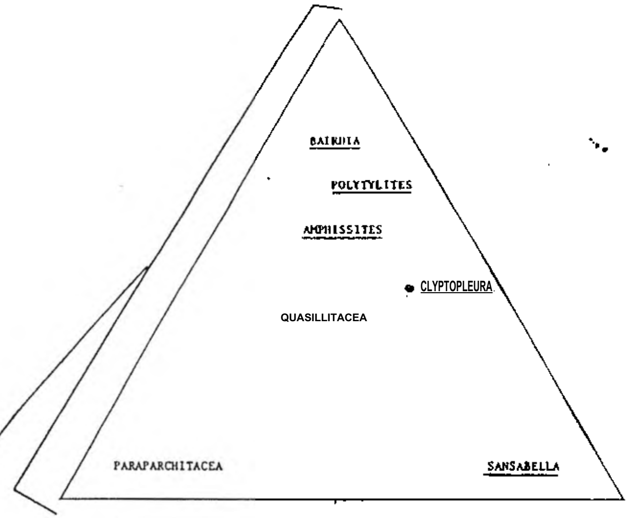
In the Black Warrior Basin, it is difficult to relate kloedenellaceans to distance from shore. It is easier to relate these forms to the physical parameters of the environment, such as substrate, terrigenous influx and salinity. Whilst these parameters are in part a function of distance from shore they do not necessarily imply 'nearshore[1] vs 'offshore' conditions, especially in situations where progradational events could bring waters of lower salinity further out onto the shelf than normal. This

a) Ostracode Assemblages for the Maritime Basin, Eastern Canada (Dewey, 1983)



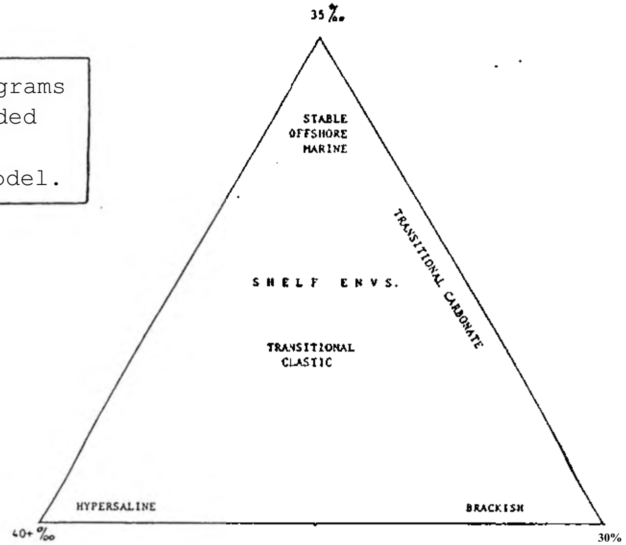
b) Ostracode Assemblages for the Black Warrior Basin, Mississippi & Alabama (herein)





c) Plot using main genera from (a) + (b): indicates area in which a fauna dominated by these forms would plot.

Note: These diagrams are intended only as a working model.



d) Possible palaeoenvironmental interpretation using salinity as the major physical control.

kind of explanation could explain why kloedenellaceans are so ubiquitous in samples from both the Pride Mountain and the Bangor.

Other ostracodes that are important in the Black Warrior Basin faunas include the healdiacean and quasi 11itacean metacopes. The healdiaceans are generally ubiquitous along an onshore-offshore gradient (Melnyk, 1985). They are therefore not very useful as a group, although individual species may show distinct palaeoenvironmental preferences.

In the Black Warrior Basin, the quasi 11itaceans have only been found in stable fine-grained sil iciclastic environments. It is probable that the distinct assemblage composed of quasi 11itaceans, the kirkbyacean genus Amphissi tes and bi nodi copes is a function of the type of shelf environments that developed in the Black Warrior Basin. It is possible that bairdiaceans and the amphissitid genus Polytylites do not appear in this assemblage because the prevailing conditions were beyond their stenotopic ranges.

Paraparchitaceans are not very common in either the Pride Mountain or the Bangor, but are normally common in nearshore environments (Sohn, 1971; Bless, 1983). By contrast, in contemporaneous hypersaline environments of eastern Canada, the paraparchitaceans dominate the fauna to almost the total exclusion of other forms (Dewey, 1983, in press). It is therefore possible that paraparchitacean-dominated faunas may be indicative of hypersaline conditions.

In both the Pride Mountain and the Bangor there are faunas which appear to represent mixed assemblages (Devery, 1987, herein). These assemblages demonstrate the gradational nature of ecological boundaries and the extent to which members of different assemblages can co-exist and tolerate alterations in physical environmental parameters.

Preliminary ternary diagrams (fig.18), that express these data, are a working model that can be refined as further data are collected. One of the important points thusfar, is that there appear to be palaeoenvironmentally distinct ostracode assemblages in the Black Warrior Basin that can identified at high taxonomic levels.

In conclusion the main ostracode assemblages that have been defined in the Pride Mountain and Bangor include:

I) Bairdiacean Assemblage, indicative of stable offshore carbonate platforms.

II) Kl oedenel lacean (<u>Sansabel la</u>) Assemblage that is indicative of 'nearshore' conditions where lowered salinities might have been a controlling factor.

III) Quasi 11i tacean-<u>Amphi ss ites</u>-Bi nodi cope Assemblage that is indicative of stable offshore fine si l iciclastic conditions.

IV) Mixed bairdiacean-glyptopleurid fauna that is transitional between the bairdiacean and <u>Sansabel 1 a</u> Assemblages in the Bangor.

V) Mixed quasil1itacean-bairdiacean-palaeocope fauna that appears to be transitional between the bairdiacean and quasillitacean-<u>Amphissites</u>-binodicope assemblages.

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