OUTCROP-BASED LITHOFACIES AND DEPOSITIONAL SETTING OF ARSENIC-BEARING PERMIAN RED BEDS IN THE CENTRAL OKLAHOMA AQUIFER, CLEVELAND COUNTY, OKLAHOMA

By

KATHLEEN MARIE KENNEY

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

2002

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2005

OUTCROP-BASED LITHOFACIES AND
DEPOSITIONAL SETTING OF
ARSENIC-BEARING PERMIAN
RED BEDS IN THE CENTRAL
OKLAHOMA AQUIFER,
CLEVELAND COUNTY, OKLAHOMA

Thesis Approved:

Stanley T. Paxton
Thesis Adviser

Richard A. Marston

Jim Puckette

A. Gordon Emslie
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my thesis advisor, Dr. Stanley Paxton, who suggested this study topic. His insight, guidance and patience determined and insured the success of this study. I am also grateful to the following committee members: Drs. Richard Marston and James Puckette whose guidance and editing of this thesis were invaluable. To the Environmental Protection Agency for providing the funding and to the Oklahoma State Parks and Recreation for their permission to study the outcrops located within Thunderbird State Park. I am indebted to all my college instructors for their help in preparing me for my career. I also want to express my appreciation to Melissa Reglan for her help and insight with the DEM stretch map. A special thanks goes to the office personnel of the Oklahoma State University School of Geology, particularly Sandy Earls, for their help throughout my undergraduate and graduate years. I would like to especially thank my parents, Eugene and Rita Kenney along with my sisters, Eileen Kenney-Patz and Karen Roder, for their help and encouragement during my collegiate study. A final and sincere gratitude goes out to my children, Niles and Michael Stuck for their understanding, support, and flexibility during the years I was absorbed in the challenges of completing my degrees.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter I

Introduction

Background

The focus of this sedimentological study is the Garber Sandstone. The Garber Sandstone is a stratigraphic unit within the Central Oklahoma Aquifer and though this study focuses strictly on the Garber Sandstone, in the literature it is frequently grouped with the Wellington Formation; collectively called the Garber-Wellington. Anderson (1927) determined the Wellington Formation has essentially the same composition as the Garber Sandstone and thus "separation of the Wellington and the Garber is therefore not possible." Green's (1937) investigations led him to believe that "the rocks of Wellington age and the Garber Sandstone cannot be separated south of northern Oklahoma County."

Tanner (1959) describes the rocks within the Garber Sandstone as "Permian age redbeds consisting of poorly lithified, fine-grained sandstones interbedded with siltstones, mudrocks and minor conglomerates." The combined thickness of a full section of the Garber Sandstone and Wellington Formation is 1,165 to 1,600 ft (Christenson et al., 1992). The amount of sandstone varies from 25 to 75 percent (Breit, 1998).

The rocks of the Garber-Wellington are distinctive for their red color which results from the presence of ferric oxides. The iron-rich mineral hematite (Fe_2O_3) is the dominant ferric oxide found in central Oklahoma. Variation in rock color is attributed mainly to differences in hematite abundance, particle size, and clustering of hematite grains (Walker et al., 1981; Torrent and Schwertmann, 1987). In nature, the morphology of authigenic hematite ranges from ultrafine pigment (grains less than 1.2μm) and microcrystalline grains to specular hematite. The red color of many rocks in the aquifer is attributed to ultrafine hematite. This pigmentary hematite is intermixed with clay minerals and is often a coating on detrital grains (Breit, 1998). Klein and Hurlbut, (1999), divide hematite (Fe_2O_3) into two general categories; the red earthy variety known as red ocher and the platy metallic variety known as specularite. It is the red ocher variety that possesses pigmentary qualities.

During the early Permian, red-colored sands were deposited and interbedded with red mud in the area of central Oklahoma. The Garber Sandstone and the Wellington Formation are two stratigraphically recognized intervals deposited in the early Permian. The Garber Formation is one of three formations within the Cisuralian (formerly Leonardian) Series. The other two formations are the Wellington (stratigraphically lower [older] than the Garber) and the Hennessey (stratigraphically higher [younger] than the Garber). Though the Garber Sandstone and the Wellington Formation are lithologically similar, Abbott (2004), through well log analysis, proposes that the Garber and the Wellington can be distinguished from each other; the Wellington having an overall greater quantity of shale than the Garber.

The Central Oklahoma Aquifer underlies approximately 3000 mi^2 in all or parts of Cleveland, Lincoln, Logan, Oklahoma, Payne, and Pottawatomie Counties (Figure 1). The Central Oklahoma Aquifer is composed of both clastic and carbonate sedimentary rocks with the Garber Sandstone serving as the nucleus of the aquifer. "All of the municipalities in central Oklahoma rely on this aquifer for all or part of their water supply" (Christenson, 1998). Therefore, the economy of Oklahoma, as well as the welfare of many Oklahoma residents, is tied to the Central Oklahoma Aquifer. Furthermore, although overall water quality is good, water-quality problems do occur in parts of the aquifer system.

Figure 1. Geographic Location of the Central Oklahoma Aquifer (Adapted from USGS)

The Problem

In January 2001, the Environmental Protection Agency established the new safe drinking water standard for arsenic at a maximum concentration of 10µg/L. Water-quality assessments for parts of the Central Oklahoma Aquifer, however, document arsenic concentrations above this standard. Arsenic is known to be toxic to humans at high concentrations (400 to 10,000 µg/L) in drinking water (Gough et al., 1979). Furthermore, arsenic is also known to be a carcinogen (U.S. Environmental Protection Agency, 1985).

Investigations by Parkhurst et al. (1989), Schlottmann and Funkhouser (1991), and Parkhurst et al. (1992) isolate the chemical controls of aqueous arsenic. In the natural environment, arsenic can exist in several oxidation states but rarely in its neutral elemental form. Varying pH and redox conditions control which aqueous arsenic species may be found within a given chemical environment. Iron, an element in the mineral hematite (Fe_2O_3) found within the Garber Sandstone, will absorb arsenic at lower pH levels but will release the arsenic into solution as the pH level rises. High concentrations of four constituents (arsenic, chromium, selenium, and gross alpha radioactivity) are known to be associated with red iron-oxide grain coatings in sandstone. These same elements require oxidizing redox conditions to be mobile. Most water sampled in the Central Oklahoma Aquifer contained 1mg/L dissolved oxygen, indicating an oxidizing condition (Christenson, 1998).

Studies by Schlottmann et al. (1998) suggest higher concentrations of arsenic tend to occur in sandstone layers that are isolated between thick layers of mudrocks. This is supported by Christenson (1998). He states, "Elevated concentrations [of arsenic, chromium, selenium, and uranium] depend on several complex geologic and geochemical conditions including . . . the distribution of mudstone."

The mudrocks of the Garber Sandstone (which contain the greater ratio of hematite in comparison to that found in the sandstones of the Garber system) affect water chemistry in many ways. First, "spatial variation in redox conditions is related to mudstone distribution," (Schlottmann et al., 1998). Also, the clay in mudrock is a site for cation exchange. Where mudrock is abundant in the aquifer the increased cation-exchange capacity results in more of the changes in ground-water chemistry that allow the trace elements to become mobile. For example, the exchange of sodium for calcium results in more alkaline conditions thus allowing the arsenic to become mobilized. Finally, the hydraulic conductivity of mudrock is lower than that of sandstone thus constituting the trace substance producing zone within the aquifer (Christenson, 1998).

Since depositional environment determines the resultant sand to mudrock ratio, the association between arsenic concentration and rock type suggests arsenic found in the potable water produced from the Permian rocks of central Oklahoma may vary with the depositional sedimentary paleoenvironment. Paleoenvironments can be interpreted through lithofacies evaluation but to date the nature of the lithofacies, as observed in outcrop, has not been systematically described for the Garber Sandstone.

This thesis is one of three concurrent studies being performed by Oklahoma State University (OSU) with funding provided by the Environmental Protection Agency (USEPA) in Ada, Oklahoma. These studies are being conducted in conjunction with researchers from the USEPA and the United States Geological Survey (USGS) and with cooperation from the City of Norman and the University of Oklahoma. The ultimate purpose of these studies is to develop strategies and recommendations that could be used for the implementation of the newly mandated governmental standards for arsenic in drinking water (< 10 μg/L). The study conducted by the School of Geology at Oklahoma State University include three theses; 1) *Subsurface Well-Log Correlation* by Ben A. Abbott (2005), 2) *Outcrop-Based High Resolution Gamma-Ray Characterization* by Gregory A. Gromadzki (2004), and 3) this thesis entitled; *Outcrop-Based Lithofacies and Depositional Setting of Arsenic-Bearing Permian Red Beds in the Central Oklahoma Aquifer*. These theses are designed to describe the sedimentary geology in and around the Norman, Oklahoma Cleveland County area. These detailed descriptions will then enable researchers to portray arsenic habitat within the context of the sedimentary geology.

The OSU strategy was to evaluate if the arsenic in the rocks varies with time (stratigraphy), with rock type (sandstone versus mudrock), with lithofacies, or a combination of the three. If arsenic levels are found to be lower in given stratigraphic intervals or in a certain lithofacies, the mapped geographic distribution of the deposits could be used to select future drilling locations for water wells. Additionally, certain zones or intervals within wells could be selectively produced therefore preventing water originating in arsenic-prone layers from entering the well bore and mixing with potable water.

In contrast to the OSU studies, the companion USGS and USEPA studies are designed to address the engineering considerations and strategies required for selectively producing low-arsenic intervals within a well bore. The USGS is also conducting regional fluid flow modeling based on geological input from the OSU geology studies.

Goals and Objectives

The goal of this study is to define and better document the characteristics of the clastic sediments and the sedimentary features found within the Garber Sandstone of Cleveland County, Oklahoma. Using the outcrop findings, it will be possible to project these characteristics into the subsurface. With a thorough understanding of the rock's character, recommendations for the drilling of new wells in areas with a lower risk of arsenic contamination can be projected.

The objectives of this thesis are to:

1. Describe lithofacies occurring in outcrops of the Garber-Wellington sandstones exposed in the Lake Thunderbird and greater Cleveland County area. The descriptions include numerous measured sections with details concerning bed thickness, lithology (including grain size, sorting, and depositional matrix content), the occurrence of primary and secondary sedimentary structures, and the nature of the bounding surfaces (bedding

planes). The nature of the lithologic succession within each outcrop is also noted, with attention to stacking patterns and the lateral and vertical continuity of the sandstones.

2. Produce a lithofacies distribution map based on the descriptions generated in #1 above.
3. Produce a grain size (mean, mode, maximum) distribution map based on the work of Gromadzki (2004) and this author.
4. Based on the above work (#1 – 3), interpret the depositional environment(s) that is most likely responsible for the accumulation and preservation of the Garber Sandstone in the Cleveland County area.
5. Produce a map showing paleocurrent directions in the Garber sandstones and the position and orientation of the thicker lithofacies sandstone packages.
6. On the basis of all the above data, make recommendations about where in the Garber sandstone outcrop-packages one would expect, in theory, to have a lower risk of encountering arsenic-bearing water.
7. Provide study results along with recommendations to Abbott (2005) for incorporation into his subsurface well log correlation – mapping study of the Garber-Wellington stratigraphic interval and provide vertical outcrop measured sections to Gromadzki (2004) for incorporation into his work.

Study Area

As previously mentioned, it is accepted practice to group the Garber Sandstone with the Wellington Formation. However, only the Garber Sandstone is the focus of this study. The Garber Sandstone interval outcrops in the study area while the Wellington Formation only exists in the subsurface, outcropping further to the east along the Cleveland – Pottowatamie County line. Bear in mind that many herein referenced researchers have grouped the two intervals together as the Garber-Wellington without necessarily distinguishing the characteristics of the Garber Sandstone per se.

The Garber Sandstone portion of the outcrop belt extends through Oklahoma in a dominantly north-south trend from Grant County on the Kansas border to Carter County where it bends to the west through Cotton, Stevens, Comanche, and Tillman Counties. The focus of the present study is in Cleveland County around the Lake Thunderbird area.

Lake Thunderbird was created in 1965 from the completion of the Norman Dam across the Little River. The lake is located 13 miles east of Norman off state Hwy 9. The topography of Cleveland County is characterized by sandstone hills and wide alluvium-filled valleys of major streams; each of which reflects the geology of the underlying rocks and the erosional effects of wind and water. Sandstone hills occupy the eastern two-thirds of Cleveland County. They are low, steep-sided hills formed by the differential erosion of lenticular beds of red sandstone and mudrock in the area of the Garber Sandstone and Wellington

Formation. The sandstone hills are strongly dissected by intermittent streams that occupy broad, relatively flat-floored alluvial valleys. Local relief ranges

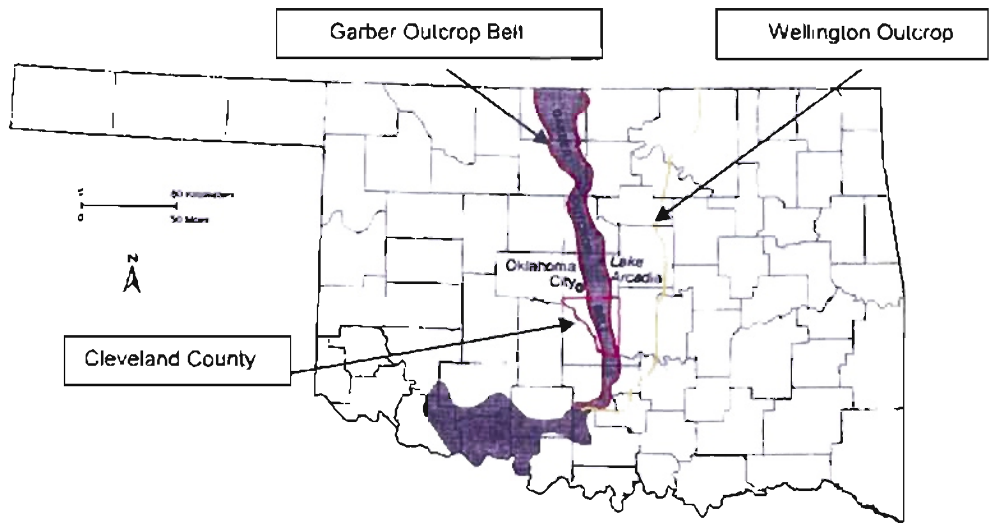


Figure 2. Map of the Garber Outcrop Belt and the Study Area (USGS)

from 50 to 200 feet. Hills underlain by sandstone are forested with small *blackjack, post oak, and other deciduous trees.* Hills underlain by mudrock are covered by grasses and commonly are barren, or nearly barren, of trees. (Wood and Burton, 1968)

Wood and Burton (1968) describe the climate of Cleveland County as controlled by the interaction of tropical and polar air masses, therefore, it is characterized by wide ranges in temperature and wide deviations from average precipitation. The average precipitation is 33.36 inches, but the seasonal range is notable, varying from 5+ inches / mo in the spring to < 1.5 inches / mo in the winter months. Norman has an altitude of 1,170 feet with an average annual temperature of about 60°F.

Chapter II

Literature Review and Previous Investigations

The Garber Sandstone and Wellington Formation

General Geology

Aurin et al., (1926) first described the Garber Formation in detail and named it for the red sandstones that can be seen in outcrop around the town of Garber in eastern Garfield County, Oklahoma. The literature regarding the Garber-Wellington Formation is limited. The first geologic information provided in writing is from investigations conducted in the 1920's and 1930's. The earliest paleoenvironmental interpretation found by this author is from Baker (1951). Through his investigations, he concluded "the presence of a uniform mineral suite, together with the relatively fine textures, cross-bedding, channeling, and lack of marine fossils, suggest deposition in a shallow inland sea or lake. The lenticularity of the sandstones indicates that they were deposited as a sheet-like delta." In 1959 Tanner published a synthesis of ideas developed from field work performed by several geologists over a period of about ten years. His work provided another paleogeographic and paleoenvironmental interpretation.

Tanner's synthesis included work on the Hunton Arch and Arbuckle Mountains, 1947; The Ouachita and Wichita Mountains, 1948; Seminole and adjacent counties, 1950 and 1951; the Ardmore Basin, 1952; Osage County, 1955 and 1956; Noble County and the Ardmore Basin, 1956. The field work was carried out in 1951, 1955, and 1956 under the auspices of the Oklahoma Geological Survey. He describes the outcrops in Cleveland County, and to the east, as "Fallis-Iconium-Garber sandstones and shales with a few conglomerates here and there. The strike is slightly west of north, and the dip westward at less than one degree." Fallis-Iconium refers to rocks of the Wellington Formation. Tanner determined the Fallis-Garber sandstones show no evidence of lagoon-and-barrier-island lithofacies, as do the clastics in Seminole County. He goes on to say that no marine invertebrates have been reported from these beds but on the other hand, coal and soot laminae are also unknown, concluding that "argument from either of these observations leads precisely nowhere. Instead, many geologists have considered the Fallis-Garber unit as a deltaic deposit."

The studies cited in Tanner's synthesis determined cross-bedding of the sandstones contain two modes oriented about 180° apart. In the central part of Cleveland County, he found Garber cross-bedding to be dominantly west or west-south-west. However, Tanner qualifies these findings by saying "very faint secondary modes, of dubious reliability, appear to the north and east". Of Pottowatomie County, to the east, he states, "Fallis cross-bedding is primarily east or east-north-east and west or west-south-west. In the two cases the minimum direction (that is the direction of least cross-bedding and hence inferred as pointing toward the source) is about S25°E." He interpreted his data as evidence that the Fallis-Garber sandstones, in good part, had a littoral origin. Tanner concluded the environments responsible for the deposition of the Garber sandstone were "fluvial, deltaic and marginal marine."

Cox (1978) and Shelton (1979) conclude that streams crossing the region transported detritus from the east-southeast toward an epeiric sea located west-northwest of Cleveland County with the sediment source being the Ouachita Uplift. The sediments produced from the erosion of the Ouachita Mountain belt included sandstone and shale. Furthermore, they concluded that the transgressive-regressive cycles of those marine waters along the shallow depositional slope probably resulted in large lateral changes in the depositional environment.

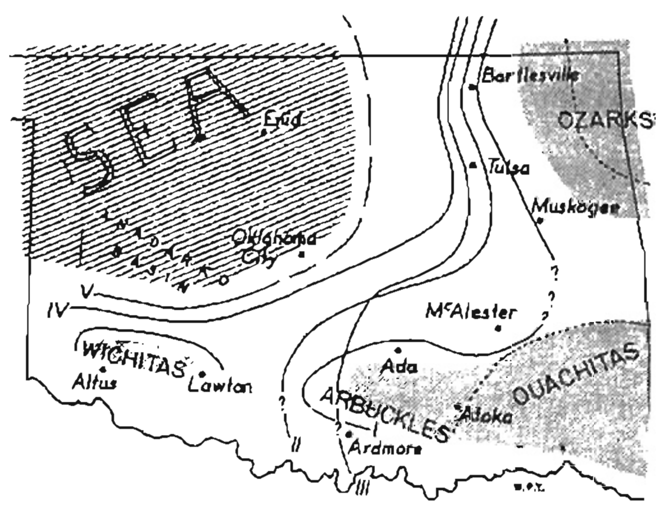


Figure 3. Paleogeographic Interpretation of Central Oklahoma by Tanner (1959). The shorelines delineated by roman numerals indicate the withdrawal of the shoreline with time.

Breit (1998) determined the sandstones found within the Garber Sandstone to be quartzarenite to sublitharenite. He further states, "both sandstone and mudrock contain the same assemblage of minerals and the sandstones are moderately sorted." Though Baker (1951) does not utilize the Folk classification scheme as did Breit, he provides detailed information regarding the type of mineral grains found within the Garber sandstones and determined them to be composed entirely of material smaller than 0.25 mm in diameter, thus placing the Garber sandstones in Wentworth's fine and very fine classifications. However, in contrast to Breit (1998), Baker determined the grains to be uniformly well sorted.

Within a geologic time framework, the Garber-Wellington is positioned in the Late Paleozoic Era, Middle Permian Period, and in the Cisuralian (Leonardian) Series. However, global correlation within the Permian is difficult because the beds are commonly terrestrial in origin. Fossiliferous marine beds are rare to absent in the Permian of Oklahoma. Therefore, chronostratigraphic divisions and subdivisions within the Permian have been, and continue to be, the subject of debate and refinement. The boundary between the Pennsylvanian and the Permain was established by the US Geological Survey in 1951. At that time, the Wolfcampian was established as the lower-most series of the American Permian succession (Dixon et al., 2001).

The International Commission on Stratigraphy (CIS) has divided the Permian System into three Series. From oldest to youngest, these Series are the Cisuralian, the Guadalupian, and the Lopingian. With the global adoption of the CIS classification scheme, the Garber Sandstone occurs in the Artinskian Stage of the Cisuralian Series (Figure 4). Placement within the Artinskian is determined by the presence of *Sweetognathus whitei* conodonts found in the Florence Limestone (Barneston Formation) of the middle chase Group and the *Rabeignathus bucaramangus* conodants found in the Winfield Limestone which is directly above the Barneston Formation. Both of these conodants are early Artinskian and though the Garber-Wellington cannot be directly dated, the presence and location of *Sweetognathus whitei* and *Rabeignathus bucaramangus* conodonts in formations immediately below the Garber Sandstone and Wellington Formation provides an estimated time placement of middle Artinskian (personal correspondence with Dr. Darwin Boardman, 2005).

During late Paleozoic time, the central and western United States, including Oklahoma, was located just to the north of the equator in the western part of the supercontinent Pangea. Some research has indicated that the equatorial region of Permian Pangea was predominantly everwet (Ziegler, 1990). However, within a very large landmass such as Pangea, the further a location is situated inland and further from the moderating influence of the circulating oceans, the increased probability it will experience harsh seasonal and climatic variability. Kessler et al. (2001) provides depositional and pedogenic evidence of seasonally wet to markedly arid conditions for western Pangea during Cisuralian (Leonardian) time. Parrish, (1993), suggests that the shift from a more zonal circulation during the Pennsylvanian to increasingly monsoonal circulation in the Permian would have resulted in equatorial aridity and marked seasonality. This climatic shift is supported by both modeling studies (Nairn and Smithwick 1976;

Parrish et al. 1982; Kutzback and Gallimore 1989; Patzkowsky et al. 1991) and geologic data (Parrish and Peterson 1988; Dubiel et al. 1991 and 1996; Parrish 1995).

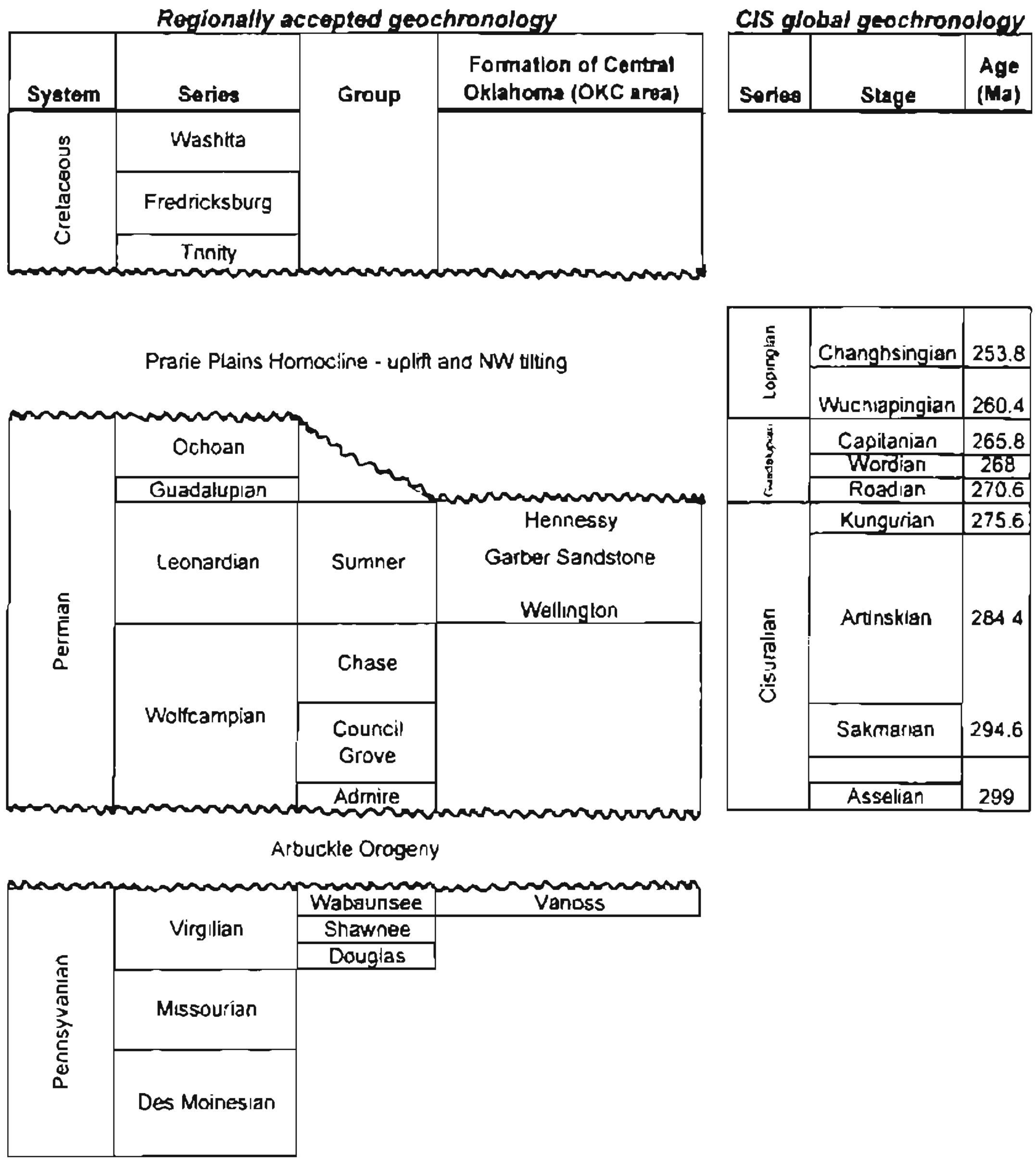


Figure 4. The Geochronology and Chronostratigraphic Units of Central Oklahoma in the Permian System. (Adapted from Cipriani, 1963 and Ogg, 2004)

Soreghan's et al. (2002) investigations into Paleozoic loessite provide further insight into the climatic and atmospheric circulation patterns common to the Upper Paleozoic of western North America. Their models suggest that Pangea's size and cross-latitudinal orientation likely produced seasonal cross-equatorial pressure contrasts, resulting in strongly monsoonal circulation. These conclusions are further supported by Kutzbach and Gallimore (1989), Patzkowsky et al. (1991), and Parrish (1993). Soreghan et al. (2002) assert that "our preliminary data are consistent with the interpretations that westerly flow associated with monsoonal circulation began by Early Permian (Cisuralian) time."

Hydrogeology

Because of the Central Oklahoma Aquifer's importance to Oklahoma, its hydrogeology was the focus of a pilot study conducted in 1991; The 1991 U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program. The primary purpose of the NAWQA Program was to assess water quality for a large part of the nation's surface and subsurface water resources. Relative to this study, many recent United States Geological Survey (USGS) investigations have centered on the geochemical and geohydrologic characteristics of the aquifer with lesser emphasis on the details of the sedimentary geology.

Christenson et al. (1998) flow modeling studies suggest that flow in the Central Oklahoma aquifer has three major components: 1) a shallow, local flow system in the unconfined part of the aquifer with transit times of tens to hundreds of years, 2) a deep, regional flow system in the unconfined part of the aquifer with transit times as much as 5,000 years or greater, and 3) a deep, regional flow system in the confined part of the aquifer, with transit times ranging from thousands to tens of thousands of years. These various components result in parts of the Garber Sandstone and Wellington Formation being unconfined while other parts are confined.

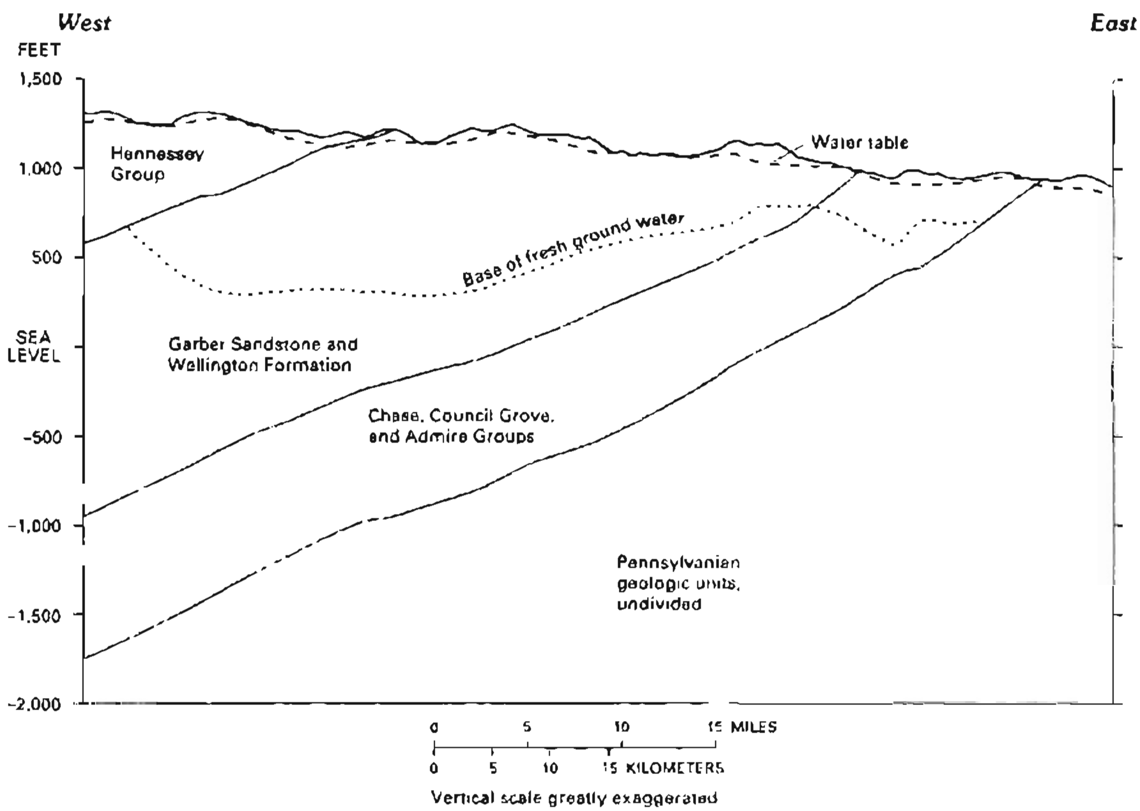


Figure 5. Cross-Section of the Central Oklahoma Aquifer (adapted from Schlottmann et. al., 1998)

Chapter III

Study Methods

Introduction

A wealth of information regarding paleodepositional environment and paleoclimate is contained in outcrops of sedimentary rock. This information can be extracted and evaluated by employing both conventional and unconventional methods of lithofacies analysis. Conventional methods include outcrop measurements (both laterally and vertically), the creation of stratigraphic columns with notation of internal sedimentary features, stratigraphic bounding surfaces, and visual examination of grain size, sorting and roundness. In an effort to more fully describe the outcrops within this study, several evaluation techniques were incorporated. Along with the conventional methods of lithofacies evaluation, a photomontage of each representative outcrop was assembled and annotated. A high resolution (30m) digital elevation model (DEM) of the study area was also used to evaluate relationships between topography and lithofacies. At the outcrop, grain size data were collected visually with the aid of a hand lens. Samples were also sieved and evaluated mathematically and graphically in the sedimentology laboratory. The combined information was then used to help define paleodepositional sedimentation patterns and lithofacies changes.

The dispersal pattern of sediments can indicate flow directions, general flow velocity, and the migration patterns of the depositional environment while the variance in grain size, grain composition, and the degree of sorting can provide clues regarding distance from sediment source lands and type of source lands. Through mapping the lithofacies and determining the depositional environment, the formation's characteristics can be projected into the subsurface. This approach can enable municipalities to make more informed decisions regarding ground-water management.

Lithofacies Descriptions

Most of the observations and lithofacies descriptions were collected from thirty-two outcrops within an approximate 35 mi^2 (90 km^2) area in Cleveland County. Most of the outcrops studied in detail occur along three east-west transects and three north-south transects along county roads. The east-west transects are along Alameda Road, Rock Creek Road, and Franklin Road. The north-south transects are along Pebbly Road, NE 180th Street, and Harra-Newalla Road. Most outcrops studied are the result of a road-cut with mechanical resurfacing performed by the highway department. Only a few outcrops are the product of natural weathering. Appendix 2 contains the detailed descriptions of all the outcrops within the transects along with another significant Cleveland County outcrop; the outcrop located east of the 120th (Choctaw) – 104th intersection. Also, an outcrop along Lake Thunderbird's western shore is incorporated as a representative of the mud-flake conglomerate lithofacies.

Other significant examples of Garber-Wellington outcrops beyond Cleveland County can be found in Oklahoma and Logan Counties along I-35, the Kilpatrick Turnpike, and the surrounding Edmond area. The area around the town of Guthrie also has several significant Garber Sandstone outcrops. Observations from these outcrops are not included in the present study.

The outcrops within the six transects of this study were examined and described in the field. Lateral measurements of each outcrop were obtained with a tape measure while the vertical measurements were obtained using a combination of a meter stick and ruler. The outcrop was initially examined in its entirety by walking the outcrop and identifying overall general architecture.

Next, the individual packages or units were isolated by identifying and describing contacts with the overlying and underlying packages. The internal structure was also evaluated along with the presence of flow indicators. Next, a location within each outcrop was chosen as a representative vertical section for that specific outcrop. The location of the vertical section was dependant upon both the attributes within the vertical section and accessibility to the outcrop face. Measurements were taken beginning at the base of each vertical section and moving up to the top. The outcrop was sub-divided into stratigraphic units by noting the presence and nature of bedding planes, internal structures, grain size and other features. One exception is the shale / laminated siltstone lithofacies. Though discussed, a representative outcrop could not be assigned since it was not the dominate lithofacies within any particular outcrop but rather is occasionally found below the erosional channel bases at various outcrops. It is the opinion of this author that though a representative outcrop can not be assigned to the shale / laminated siltstone lithofacies, its significance toward a paleoenvironmental interpretation warrants its classifications as a lithofacies. Furthermore, the sieved grain size analysis was limited to sandstones and is therefore not offered for the mudstone or the carbonate clast conglomerate lithofacies. All lithofacies are discussed in greater detail in the following sections.

Descriptions and subdivisions of the sandstones within some outcrops are difficult. This is because the sandstones within these outcrops are poorly cemented and friable. Evidence suggests that some of these rock's fresh exposures were soft and very compressible at the time they were exposed to the surface during road construction. With the passing of time, many of the outcrops develop a hard outer casing. Many of these road-cut outcrops appear to have undergone mechanical re-surfacing immediately after exposure thus superimposing an artificial surface over the natural surface. In some cases these conditions have masked bedding and internal sedimentary structures. Individual units within each vertical section were examined for internal structure, grain size, grain sorting, and color. The geographic location of each vertical section is given in reference to a specified end of the outcrop. Please refer to Figure 7 for the base map of transect and outcrop locations for this study.

Figure 6. Permanent Tire Tread Marks on Garber Sandstone. This photo illustrates the sandstone's susceptibility to compaction and deformation soon after initial exposure but prior to the development of outer case hardening. The details of the case hardening are not addressed within this study.

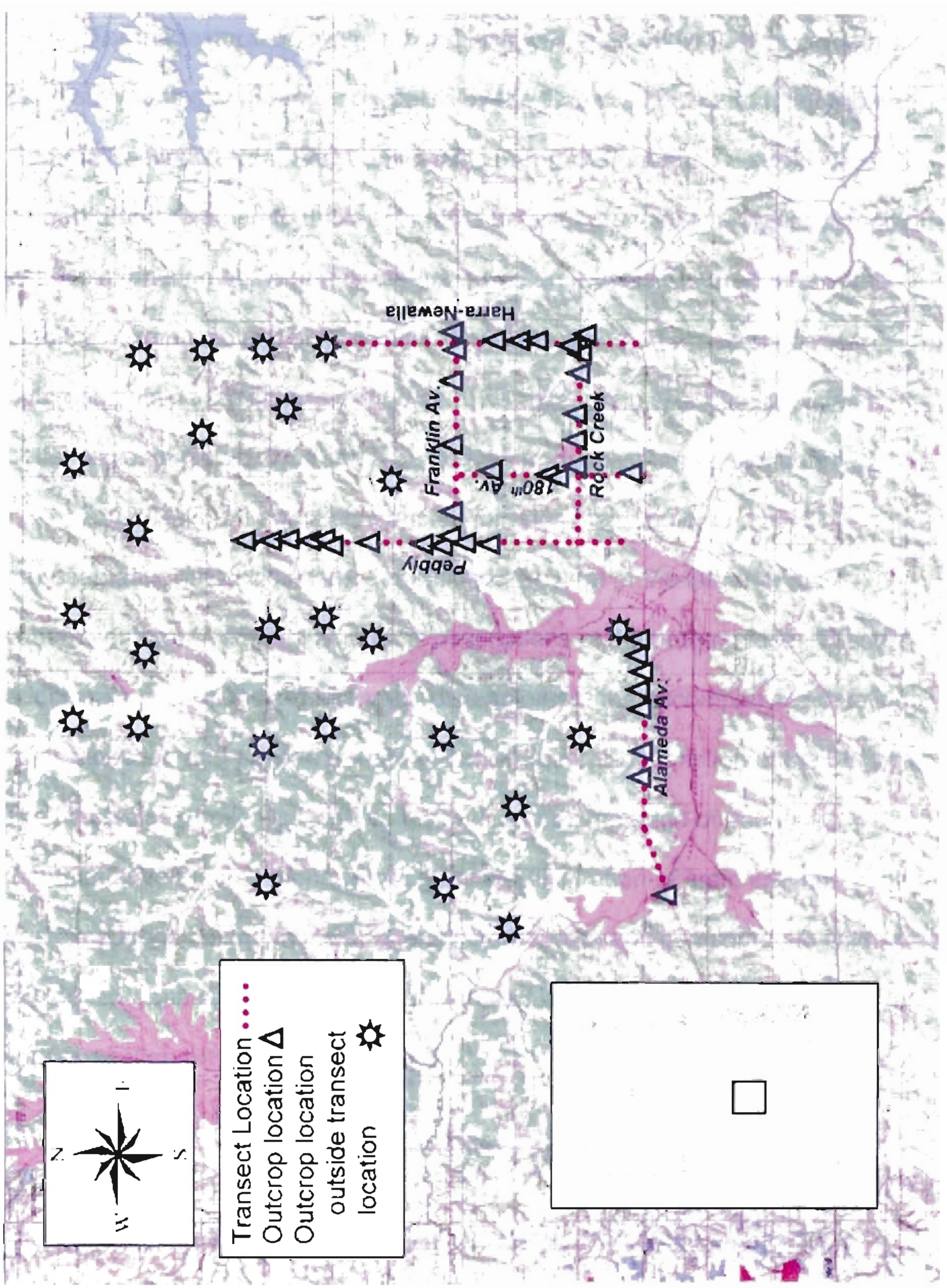


Figure 7. Base Map and Transect Locations.

For the textural analysis, a hand lens was used in the field along with a grain size/sorting comparator prepared by the Gamma Zeta Chapter of Sigma Gamma Epsilon at Kent State University. Samples from each outcrop were gathered and returned to the lab for more detailed grain size analysis. A more in-depth explanation of the laboratory grain size analysis is provided later in this chapter. Grain size and sorting evaluation were also performed on several outcrops outside the study's transects. This extra grain size data provides a better regional picture than could be derived from only the transect data.

A vertical profile was constructed for each major outcrop and representative lithofacies were determined. Several of the larger or more variable outcrops required additional descriptions of the outcrop face. These additional descriptions are intended to complement the accompanying detailed vertical section and provide a more enhanced overall description of the outcrop. The lithofacies profile was also paired with a photomontage of each representative outcrop along with a graphical illustration of grain size and sorting. The exceptions being the mudstone and carbonate-clast conglomerate lithofacies (no sieved grain size analysis) and the shale / laminated siltstone lithofacies (no vertical section or grain size analysis).

Sedimentary Structures

Primary sedimentary structures form as a result of the processes of erosion, transportation, and deposition. Therefore, a sedimentary structure can be used to interpret ancient sedimentary processes. Through evaluation and interpretation of both the geometry and the internal characteristics of a sand lithosome, accurate determination of the depositional environment or genesis of the sand body is possible (Shelton, 1973).

A fundamental characteristic of sedimentary rocks is bedding. Beds are tabular or lenticular layers of sedimentary rock that have lithologic, textural, or structural unity that clearly distinguishes them from the surrounding layers. A sedimentary bed can be produced very rapidly by a single event such as a flood & / or a gravity flow down a slope. A bed can also form very slowly in the case of very fine clay sized grains in suspension. Such clay sized grains can take months or even years to settle out of suspension and produce a bed (Boggs, 2001).

Bedding surfaces, or bounding planes, separate vertically stacked beds and are known as bedding planes. The bedding planes of a bed are the upper and lower surfaces of the bed. The bedding planes of sedimentary beds can be described as curved, wavy, or even (Campbell, 1967). Furthermore, curved, wavy, and even beds are either parallel or nonparallel (Figure 8). A marked discontinuity (commonly an erosional surface) between two beds of similar composition is called an amalgamation surface and the beds separated by such surfaces are called amalgamated beds (Boggs, 2001).

In 1953, McKee and Weir first proposed a scheme for bed thickness and defined a bed as a stratum thicker than 1 cm. However, Campbell (1967) and Ingram (1954) believed that beds have no limiting thickness and can range in thickness from a few millimeters to tens of meters but are usually measured in centimeters. Campbell and Ingram designated 'beds' less than 1 cm as lamina. Currently accepted terms used for describing the thickness of beds and lamina are in agreement with Campbell and Ingram. These terms are summarized in Figure 9.

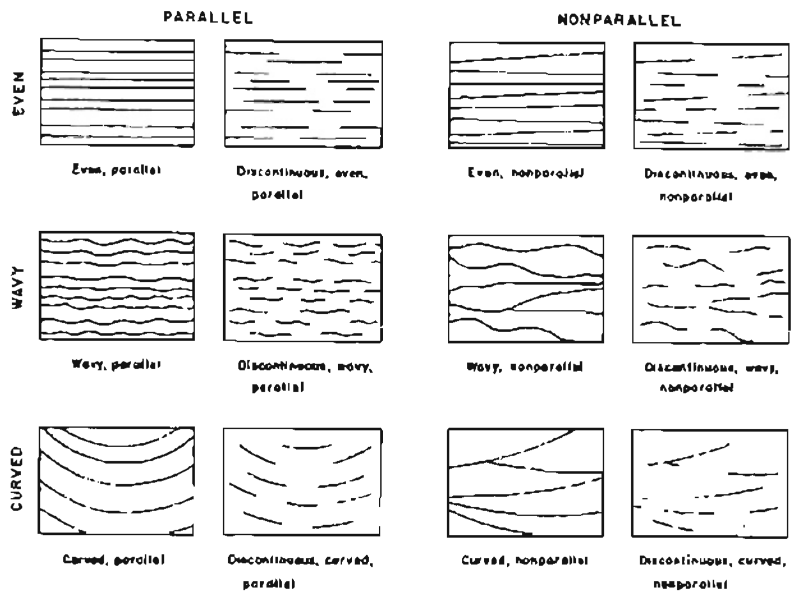


Figure 8. Descriptive Terms Used for the Configuration of Bedding Planes (Campbell, 1967).

Cross-bedding is probably the commonest type of internal bedding a geologist encounters. Cross-bedding has been recognized since the 1800's and described from sediments of all ages and from every part of the world (Reineck and Singh, 1975). Cross-bedded sandstones can be defined as a single layer, or a single sedimentation unit consisting of a series of internal lamina inclined to the principal surface of sedimentation. This definition is in accordance with Reineck and Singh (1975), Otto (1938), and Potter and Pettijohn (1963). The thickness can vary from a few centimeters to several meters. Generally, the inclined lamina seen in cross-bedding illustrates a two dimensional view perpendicular to the migrating direction of the ripple that formed the lamina. The direction of ripple migration indicates the direction of current flow at the time of deposition. Therefore, cross-bedding can serve as an important paleocurrent indicator.

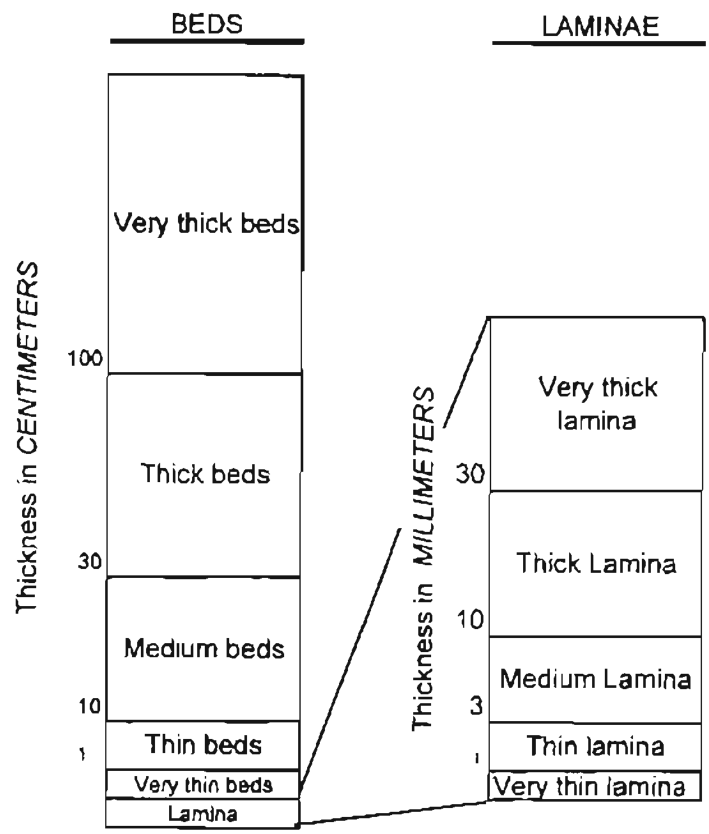


Figure 9. Terminology for Thickness of Beds and Lamina. (Adapted from McKee and Weir 1953, Ingram, 1954, Campbell, 1967)

There are two major classes of cross-bedding based on the geometry of the bounding surface; tabular and trough. It is important to note that distinction and recognition of these major types of cross-bedding depends on having a three-dimensional view. "Depending on angle of view, trough cross-bedding can, at times, appear as tabular cross-bedding," (Reineck and Singh, 1975).

Cross-bedding can originate in several genetically different ways. Most result from the migration of ripples (defined as less than 20 cm in length) or dunes (defined as greater than 20 cm in length). Any environment with noncohesive sediment can produce ripples (or dunes) and therefore, cross-bedding. Cross-bedding is abundantly developed in sandy intertidal flats, shoals, alluvial valleys, and in deep sea sediments where a current is available. To a lesser degree cross-bedding is also found in lacustrine and fluvio-glacial environments (Reineck and Singh, 1975). In other cases, cross-bedding can be the result of channel-fill features, deposition on the point bars of small meandering channels, or on the inclined surfaces of beaches and bars.

Massive bedding is used to describe beds that appear homogenous and lack internal structure. The lack of stratification has been assumed to be a primary feature resultant from the absence of traction transport and very rapid deposition from suspension or deposition from very highly concentrated sediment dispersions during sediment gravity flows (Boggs, 2001). Though to the unaided eye these beds appear to lack internal structure, Hamblin (1965) determined that often very faintly developed structures could be seen with X-radiography techniques. Massive, or faintly developed structures, are commonly the result of uniform grain size within a bed or amalgamated beds.

Erosional surfaces are key sedimentary features. Channel forms commonly result from erosion of a substrate. Erosion results in a distinct boundary separating channel fill from the underlying strata. The sediments within channels may be characterized by a granule or pebble basal lag with tabular or trough cross-bedding above the basal lag. The lag deposits are commonly composed of the underlying lithology. Erosional channel bases are common in alluvial valleys, deltas, and in some marine environments.

The Garber Sandstone has been described by previous researchers as "fluvial, deltaic and marginal marine" (Tanner, 1959). Such descriptions produce expectations of specific sedimentary structures within the Garber Sandstone. For example, within a fluvial system one would expect to find the following sedimentary features:

- Scoured / erosive bases of channels
- Crevasse-splay / over-bank deposits
- Longitudinal, transverse, and point bars
- Sediment dominated by sand and mud as a subordinate constituent
- Planar lamina and / or beds
- Ripple lamina and / or beds
- Trough and tabular cross stratification
- Lateral migration of the channel and channel fill
- Few fossils, no marine fossils
- Red coloration due to oxidation
- Paleosol development and rooting in flood plain mudstones
- Variable but unidirectinal paleo-current direction
- Heterolithic channel fill that fines upward

A deltaic system may possess:

- Very fine to fine-grained sandstones interbedded with carbonaceous shales
- Lenticular and flaser bedding
- Abundant current ripples
- Bouma sequences off the delta front (see Bouma, 1962)
- Brackish to marine fossils
- Sole markings which may include flute casts, prod marks, and grooves.
- Overall coarsening upward sequence

Sedimentary features within a marginal marine and tidal setting may include:

- Wave ripples
- Well developed marine parasequences
- Marine fossils
- Hummocky bedding
- Evidence of bioturbation
- Flaser bedding
- Evidence of some current reversals (herringbone cross-beds)
- Rhythmic sedimentation (sand-mud couplets)

Paleocurrent Analysis

Paleocurrent analysis is necessary to determine the direction ancient currents were flowing at the time of deposition. The dip direction of cross-bed foresets, the asymmetry and orientation of the crest of current ripples, the orientation of erosional troughs, flute casts, groove casts, current lineations (also referred to as parting lineations), and the trend of erosional channels are all paleocurrent indicators. Another sedimentary feature useful in determining paleocurrent direction is the accretion surface on point bars. The accretion surfaces of point bars are commonly at right angles to current flow. Internal cross-bedding is one of the most useful sedimentary structures for determining paleocurrent direction. Because the foreset laminae in cross-beds are generated by avalanching on the downcurrent (or lee side) of the ripple or dune, the foresets dip in the down-current direction. The most accurate paleocurrent measurements from cross-beds are obtained from outcrops with a three-dimensional view. First, the dip of the foreset lamina is determined. Once the dip is determined, the strike of the foreset is 90° (perpendicular) to dip. However, keep in mind that in some settings one must correct for any tectonic tilting. (Collinson and Thompson,1989).

Flow can be classified as unidirectional, bidirectional, and polydirectional. Unidirectional flow is most commonly observed in fluvial and deltaic environments. Bidirectional flow can result from the tidal action of a shallow marine or littorial environment. Polydirectional current indicators can result from a mixture of different transporting medium, such as water and wind, or changes in weather or climate patterns. Paleocurrent data are most useful when plotted on a regional scale to reveal regional paleocurrent patterns (Boggs, 2001).

DEM Stretch Map

A stretch map is a form of slope map based on the standard deviation of slope percent for an entire DEM relative to each cell. The form of stretch map used in this study displays higher slopes in white tones and lower slopes in gray. The lowest slope is black. For this study, a 30 m resolution DEM was used to characterize the topography as an aid to mapping lithofacies. Slope was calculated from the DEM using a moving 3 x 3 cell of pixels. See Belt and Paxton (2005) for discussion of details.

A study by Belt and Paxton (2005) illustrates that local topographic variation in north central Oklahoma is dependent on the relative proportion of sand to mudrock in the underlying bedrock. Their findings suggest that the presence and thickness of sandstone, even if weakly consolidated, plays a role in determining topographic expression of bedrock. Therefore, along with the conventional field techniques of outcrop evaluation, the use of DEM data sets and stretch maps can be used to delineate subtle topographic changes that reflect mean subsurface geology. The present study tests the hypothesis that a DEM stretch map may be used in regional lithofacies analysis.

Laboratory Grain Size Analysis

Grain size is a fundamental attribute of sedimentary rocks and thus an important descriptive property. "The sizes of particles in a particular deposit reflect the weathering and erosion processes which generate particles of various sizes and the nature of subsequent transport (and depositional) processes" (Boggs, 2001). Siliciclastic sedimentary grain sizes can range from clay-size particles that require a microscope for visualization to boulders several meters in diameter.

A study of grain size involves four phases; (a) determining an appropriate technique for measuring grain size and expressing it in terms of some type of grain-size or grade scale, (b) measuring the grain size, (c) utilizing methods for summarizing large amounts of grain size data and presenting them in graphical or statistical form so that they can be more easily evaluated. and (d) interpreting the genetic significance of these data (Boggs, 2001).

All numerical grain sizes discussed in this study are expressed in the value phi (ϕ). The phi scale is derived from a grain scale first proposed by Udden in 1898 then later modified and extended by Wentworth in 1922. This original millimeter grain scale became known as the Udden-Wentworth scale. The Udden-Wentworth scale ranges from < 1/256mm (0.0039mm) to > 256mm and is divided into four major categories; clay, silt, sand, and gravel. In 1934, Krumbein altered the Udden-Wentworth scale by translating the mm size categories into phi units. The phi scale is based on the relationship

$$\phi = -\log_2 d$$

where ϕ is phi size and d is the grain diameter in millimeters. Because sand-size

U.S. Standard sieve mesh		Millimeters	Millimeters	Phi (ϕ) units	Wentworth size class
Gravel		4096		-12	Boulder
		1024		-10	
		256	256	-8	
		64	64	-6	Cobble
		16		-4	Pebble
	5	4	4	-2	
	6	3036		-1.75	Granule
	7	2.83		-1.5	
	8	2.38		-1.25	
	10	2	2	1.0	
Sand	12	1.68		-0.75	Very coarse sand
	14	1.41		-0.5	
	16	1.19		-1.25	
	18	1	1	0.0	
	20	0.84		0.25	Coarse sand
	25	0.71		.5	
	30	0.59		0.75	
	35	0.5	1/2	1.0	
	40	0.42		1.25	Medium sand
	45	0.35		1.5	
	50	0.3		1.75	
	60	0.25	1/4	2.0	
	70	0.21		2.25	Fine Sand
	80	0.177		2.5	
	100	0.149		2.75	
	120	0.125	1/8	3.0	
	140	0.105		3.25	Very fine sand
	170	0.088		3.5	
	200	0.074		3.75	
	230	0.0625	1/16	4.0	
Mud / Silt	270	0.053		4.25	Coarse silt
	325	0.044		4.5	
		0.037		4.75	
		0.031	1/32	5.0	
		0.0156	1/64	6.0	Medium silt
		0.0078	1/128	7.0	Fine silt
		0.0039	1/256	8.0	Very fine silt
Mud / Clay		0.002		9.0	Clay
		0.00098		10.0	
		0.00049		11.0	
		0.00024		12.0	
		0.00012		13.0	
		0.00006		14.0	

Table 1. The Wentworth Grain-Size Scale for Sediments. Comparison of Wentworth size classes, U.S. Standard sieve numbers and various millimeter and ϕ sizes are illustrated.

and smaller grains are the most abundant grains in sedimentary rocks, Krumbein chose the negative logarithm ($-\log_2$) of the grain size in millimeters so that grains of smaller sizes (which are the most common) will have positive phi values thus avoiding the bother of constantly working with negative numbers. The data collected from each sampled outcrop was summarized in an Excel spreadsheet format (Appendix 3). The statistical parameters for each outcrop were calculated directly through the use of the mathematical method of moments (Krumbein and Pettijohn, 1938). By combining the attributes of this statistical method with Excel, graphical representations of grain sizes and their distribution was then formulated. The method of moments technique was not used extensively until comparatively recently (since the 1980's) because of the laborious calculations involved and because it had not been demonstrated that moment statistics are of greater value than graphical statistics in application to geologic problems. However, with the advent of modern computers, lengthy calculations no longer pose a problem and moment statistics have gained in popularity. The computations in moment statistics involve multiplying the weight frequency in percent by the distance from the midpoint of each size grade to the arbitrary origin of the abscissa (Krumbein and Pettijohn, 1938). The formulas for calculating grain-size parameters by the moment method are shown in Table II.

The grain size summary parameters evaluated for sandstone samples obtained at each outcrop are mean, mode, sorting, and skewness. While the mean grain size indicates the average grain size for a particular outcrop, the mode represents the grain size occurring most frequently within an outcrop. The standard deviation is the mathematical expression of grain size sorting.

Mean (1st moment)	$\bar{x}_\phi = \frac{\Sigma fm}{n}$
Standard deviation (2nd moment)	$\sigma_\phi = \sqrt{\frac{\Sigma f(m - \bar{x}_\phi)^2}{100}}$
Skewness (3rd moment)	$Sk_\phi = \frac{\Sigma f(m - \bar{x}_\phi)^3}{100\sigma_\phi^3}$
Kurtosis (4th moment)	$K_\phi = \frac{\Sigma f(m - \bar{x}_\phi)^4}{100\sigma_\phi^4}$

where f = weight percent (frequency) in each grain-size grade present
m = midpoint of each grain-size grade in phi values
n = total number in sample; 100 when f is in percent

Table II. Formulas used in Calculating Grain-Size Parameters using Method of Moments (Krumbein and Pettijohn, 1938).

Assuming a normal distribution, one standard deviation about the mean encompasses the central 68 percent of the area under a bell-shaped frequency curve. Therefore, 68 percent of the area under a frequency curve is within plus or minus one standard deviation of the mean size. Table III compares the sorting descriptions with the corresponding range of standard deviations for each sorting class.

< 0.35 ϕ	very well sorted
0.35 – 0.50 ϕ	well sorted
0.50 – 0.71 ϕ	moderately well sorted
0.71 – 1.00 ϕ	moderately sorted
1.00 – 2.00 ϕ	poorly sorted
2.00 – 4.00 ϕ	very poorly sorted
> 4.00 ϕ	extremely poorly sorted

Table III. Standard Deviation Values Translated to Sorting Descriptions (Folk, 1974)

Skewness is the quantitative analysis of a frequency curve's symmetry; the greater the skewness, the greater the inequality in the presence of the finest or largest grain sizes in relation to the mean grain size. Populations that have a tail of excess fine particles are positively skewed whereas populations with a tail of excess coarse particles are negatively skewed (Folk, 1974).

Grain-size frequency curves also illustrate various degrees of sharpness or peakedness. This is called kurtosis and is commonly calculated along with the other grain size parameters. However, "the geological significance of kurtosis is unknown, and it appears to have little value in interpretative grain size studies" (Boggs, 2001).

Grain size data for this study were collected independently by both G. Gromadzki and K. Kenney. The combined aerial extent of sampling was approximately 200 mi^2 (484 km^2). Gromadzki's data covered the six transects while this author collected samples to the north and west of the general transect region. Gromadzki's sampling encompassed 36 outcrops with a total of 413 samples. Kenney's data were collected in an effort to document the grain size variability beyond the transect boundaries. Kenney's sampling encompassed 24 additional outcrops with a total of 51 samples gathered in a sampling strategy similar to that of Gromadzki (2004). Samples were taken from the base of each outcrop to the top and represent the discreet sandstone units within each outcrop. Each sample was placed in a bag and labeled appropriately. The approximate average weight of each sample was 230 gms.

After samples were collected and labeled, they were then returned to the Oklahoma State University School of Geology sedimentology lab and processed through U.S. Standard Sieves and an electronic RoTap sieve shaker for 10 minutes per sample. Using an electronic scale, a weight of each grain size class was measured and the weight percent was calculated for each class. The cumulative weight percent was calculated by adding the weight of each succeeding size class to the total of the preceding classes. Both graphical and mathematical treatment of the grain data was then employed to summarize the data and illustrate the variation in grain size within and between the outcrops.

Strength (Coherence) and Hardness of Rocks and Sediments

A material's strength is defined as its resistance to breaking under compression while its hardness is the material's resistance to scratching or grinding. Strength varies with degree of coherence and for most clay-rich materials, with moisture content (Compton, 1985). The scale used in this study is adapted from a Compton (1985) technique. This scheme is not a universally accepted or rigorous technique but offers a useful comparison between the rocks studied in outcrop.

Scale of strength:

1. *Loose*. Sediment flows when dry and thus cannot be sampled in aggregate.
2. *Very friable*. Sediment crumbles so easily that pieces are difficult to collect intact.

3. *Friable*. Sediment crumbles under light pressure in the hands.
4. *Somewhat friable*. Rock breaks in the hands under moderate pressure.
5. *Firm, slightly friable*. Rock breaks with difficulty in the hands but readily by hammer blows
6. *Weak, nonfriable*. Rock cannot be broken in the hands but breaks under light hammer blows
7. *Moderately strong*. Rock breaks under moderate hammer blows.
8. *Strong*. Rock breaks under hard hammer blows, sounding with a ring.
9. *Very strong*. Rock difficult to break with hammer, sounding "boink."
10. *Unusually strong*. Rock impossible to break with hammer, sounding like steel.

Chapter IV

Results and Discussions

Lithofacies and Lithofacies Associations of the Garber Sandstone

In an effort to better define the paleodepositional environment and the regional stratigraphic framework, the present study centers on the details of the lithofacies and sedimentary structures found in outcrop in the Lake Thunderbird area. Lithofacies are distinguished by physical characteristics such as color, lithology, texture, internal sedimentary structures, and bedding character. The evaluation of the 41 outcrops within this study has led to a classification scheme of eight lithofacies: 1) thick to very thick massive sands, 2) ripple laminated sandstone of variable thickness, 3) horizontal to low angle planar laminations of variable thickness, 4) tabular and trough cross-beds, 5) carbonate-clast conglomerates, 6) mud-flake conglomerates, 7) mudstones, and 8) shale / laminated siltstones.

Environmental interpretation of ancient sedimentary environments is greatly enhanced through the study of lithofacies associations and successions. A key to environmental interpretation is to analyze all of the lithofacies together, that is, to study the entire conformable stratigraphic successions in which the different lithofacies occur. "One of the single most important concepts in stratigraphy is Walther's Law" also referred to as the law of the correlation (or succession) of lithofacies (Boggs, 2001). Walther defined that a direct environmental relationship exists between lateral lithofacies and vertically stacked or superimposed successions of strata. The vertical succession and lateral variation of lithofacies can contribute as much environmental information as the characteristics of the individual lithofacies themselves.

Flow strength is a key parameter determining sedimentary structures. Flow strength is divided into upper and lower flow regimes with the division between regimes defined by the Froude number 1. If the Froude number is < 1, the flow strength is considered to be a lower flow regime; also described as tranquil, streaming, or subcritical. In the low flow regime, the sediment is being transported and deposited onto the surface of the bed in a manner out of phase with the surface of the flow. This allows the formation of ripples and/or dunes along with resultant cross-bedding. Flow strength with a Froude number > 1 is considered the upper flow regime; also described as rapid, shooting, or supercritical flow. In a high flow regime sediment transport and deposition onto the surface of the bed is in phase with the surface of the fluid thus resulting in the formation of plane beds and parting lineations. If flow velocity continues to increase, there will be point of no deposition and only erosion (shoots and pools) will exist.

The following is a discussion of the lithofacies classifications for the Garber Sandstone in Cleveland County as determined through this study.

1. Thick-to-very-thick massive bedding: massive bedding is used to describe beds that appear to be homogenous and lack internal structure. Though this type of bedding is commonly formed as a result of the rapid deposition from gravity flows or when a sediment load overcomes the capacity of the river, massive bedding can also result within homogenous fine-grained sands. Reineck and Singh (1975) believe the term "homogenous bedding" (massive bedding) should be used in only specific cases, where all methods (including X-ray and thin sections) fail to decipher internal arrangement". However, this author uses the term in referencing cases where gross appearance fails to reveal any internal structure. The massive bedding seen in the Garber sandstones is most likely a result of uniform grain size. Massive bed thickness varies within the study area from approximately 30cm to 600cm; most of the thickest beds being found in the north and northeastern parts of the study area.

2. Ripple beds and laminations: ripple beds and lamina form in the lower flow regime with a mean flow velocity of less than 60cm/s but greater than 10cm/s (Prothero and Schwab, 2003). Two broad types of ripples are current ripples (found in many environments including fluvial systems) and wave ripples (commonly found in marine settings). Current ripples are formed as a result of unidirectional flow thus resulting in asymmetrical ripple geometry whereas wave ripples, also referred to as oscillation ripples, are symmetrical because of the equal energy of the forward and backward motion of the wave. Within the Cleveland County study area only current (unidirectional) ripples are noted. The

only bedding plane ripples found within the study area is at the outcrop on Alameda Road by the bridge. Unfortunately, the slab is not in place and its original location in the outcrop could not be determined. Other ripple beds and laminations observed exist as forests or cross-beds. These ripple beds and lamina exist in units of varying thickness. Commonly, beds are composed of ripple lamina but other beds have ripples without distinct laminations. The overall bed thickness varies from approximately 10cm to 60cm; many of the thickest beds being found in the north-northeastern parts of the study area.

3. Horizontal to low angle planar thin bed or laminations: horizontal to low angle planar laminations are produced in upper flow regimes and are marked by Froude numbers greater than 1, thus indicating that the flow has become rapid, shooting, or supercritical. As flow strength increases into the upper flow regimes, ripples are unable to form (Prothero and Schwab, 2003). In the Garber Sandstone, low angle planar laminations probably reflect a flow strength that was transitioning from a lower flow regime to an upper flow regime. Increased flow strength can be produced by several means; one being when a volume of water exceeds the volume capacity of the space in which it flows. Frequently but not consistently, the horizontal to low angle planar thin beds and / or laminations observed in the Garber Sandstone of Cleveland County are seen in the upper reaches of the outcrops. This indicates that a shallowing of water may have existed and been in part the result of decreased accommodation space within the Garber Sandstone channel as sediments filled the channel. Another explanation of the presence of horizontal to low angle planar thin beds and / or lamina,

particularly outside of the channels, may be intermittent sheet floods. Within this study area, the beds with an internal structure of horizontal to low angle planar thin beds and laminations vary in thickness from approximately 15cm to 60cm.

4. Tabular and trough cross-beds: tabular and trough cross-beds "are probably the commonest types of bedding that geologist encounter" (Reineck and Singh, 1975). In most cases, cross-bedding or cross lamina is a result of the migration of ripples or dunes thus reflecting the lower flow regime in deeper water. Tabular and trough cross beds are terms applied to the geometric shape seen within a bed between the bed's bounding surfaces. Tabular and trough cross-bedding provides some evidence for a fluvial paleoenvironment. The thickness of the tabular and trough cross-beds found within this study vary from approximately 20cm to 70cm.

5. Carbonate clast conglomerates: the conglomerates found within this study are pencontemperaneous and formed from intrabasinal sediments. These conglomerates are composed of gravel and sand existing in the substrate and were probably ripped-up during flood events. These fragments were then deposited after only minimal time / distance transport. After deposition as gravelly debris on the substrate, the sediments became cemented by carbonate (calcite and dolomite) and sometimes hematite. Internal structure varies from massive to graded bedding while some of the units observed on the shore of Lake Thunderbird contain trough cross-beds. The broad shallow trough conglomerates vary in composition and contain carbonate clasts that appear to be caliche and concretions derived from the underlying mudrocks. The

conglomerates commonly contain a matrix of sand grains. These conglomerates are likely the product of broad regional flooding events producing overland sheet flow and / or focused flow at the base of major channels. The bed thickness of the carbonate clast conglomerates varies from approximately 8cm to 30cm. Possibly the most notable carbonate clast conglomerate outcrop within the study area is on Pebbly Road, approximately 5.2 miles north of Little Axe park entrance; a unit 170 cm thick composed of nine stacked thin to medium sized beds.

6. Mud-flake conglomerates: The mud-flake conglomerates are unique from the carbonate clast conglomerates in that the only clasts visible are mud clasts or flakes. Mud-flake conglomerates are poorly cemented, and erode easily. These conglomerates too reflect pencontemperaneous intrabasinal sedimentary processes. Within a monsoonal environment with high temperatures and little to no vegetation stabilizing the surface, shallow waters with suspended silts and clays quickly evaporate resulting in a muddy substrate within the flood basin. As the Permian waters evaporated under similar conditions, mud cracks would have formed with desiccating mud layers curling up and pulling away from the crack's perimeter. The desiccated mud curls were easily eroded by the flash flooding resultant of intermittent heavy rains. During rapidly falling flood stage these pencontemperanious mud-flake sediments became deposited to form mud-flake conglomerates. The only mud-flake conglomerate found within this study's area is along the shore of Lake Thunderbird and is approximately 10 cm in thickness.

7. Mudstone: the mudstone lithofacies within the Cleveland County study area is composed of clay and silt sized grains with no internal sedimentary structures. However, this lithofacies uniquely exhibits the intermittent presence of soil formation indicators such as glaebules, rhizocretions, soil related carbonate deposits, and slickensides. These deposits, because of rapid weathering, are not common.

8. Shale / laminated siltstone: the shale / laminated siltstones lithofacies results from deposition in very slow moving to quiescent waters. Water must be relatively quiescent before shale and silt can be deposited. The laminated geometry results from variation in settling conditions or possibly seasonal variations. Within this study, shale and laminated siltstones are generally found below and truncated by an erosive base of a channel and commonly contains packages of fine grained ripple laminated sandstones with mud drapes. Shale and laminated siltstones weather rapidly thus having a limited presence in the outcrops of the Lake Thunderbird study area. This study proposes that this lithofacies represents flood plain deposits. The quiescent waters may have been existed as temporary lakes formed after a flood event. Wind blowing across the water as clay to silt sized particles settled could possibly have produced the lamination seen within this lithofacies.

Lithofacies associations found within this study suggests cyclic channel filling sequences. A common representative lithofacies association found in the Garber Sandstone is basal mudstone / laminated siltstones eroded by high velocity water flow forming a relatively low-relief erosional surface. This event is followed by the deposition of the basal sand units which are generally massive but also exist, however less frequently, as tabular and trough cross-beds. In some locations, the basal sand units of the channel are underlain by structureless mudrock. Mudrock deposited on the channel base suggests slack water existed in the channel for a period of time after the channel was cut. This suggests that the event responsible for cutting the channel is not related to the immediate deposition of the sandy or conglomeratic fill that exists above the mud. This observation can be further extended to suggest that events responsible for cutting channels are not necessarily related to events responsible

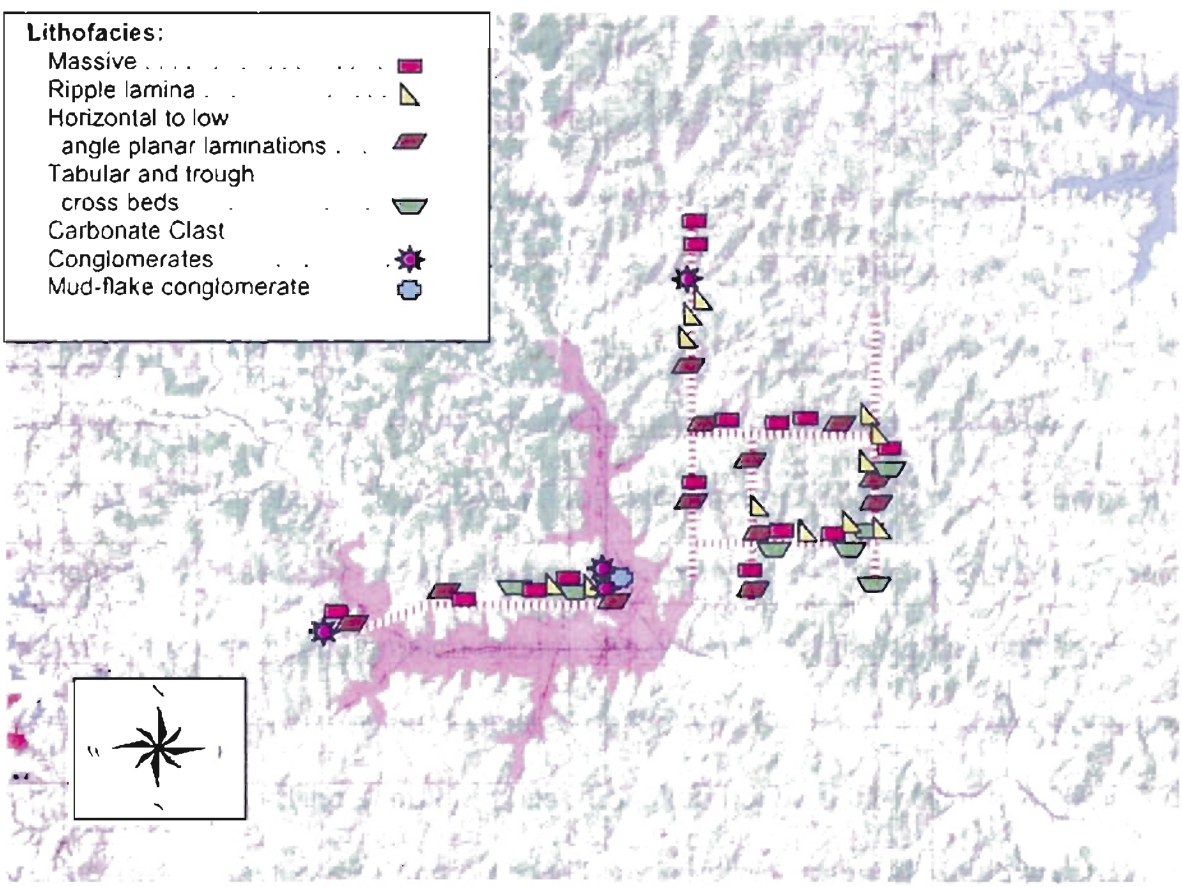


Figure 10. Lithofacies Distribution Map

for basal sand or conglomerate deposition. As the flows gradually recede, thin beds of ripples form. However, as the accommodation space fills and the channel becomes shallower, the water flow strength will increase. This provides a possible explanation of why the top of outcrops within the Lake Thunderbird study area commonly exhibit planar thin beds and / or laminations of fine grained sandstones. Where present, mudstones overlay or exist between laterally spaced sandstones. The lithofacies associations found within the Garber Sandstone indicate a system that was dominantly a meandering fluvial paleoenvironment

A generalized and ideal in-filling succession of a fluvial channel in the Lake Thunderbird area is illustrated in Figure 11. Initially, the force of the water flow cuts a channel truncating the underlying muds to form a relatively low-relief erosional surface (a). Following the initial stage of channel downcutting, intrabasinal carbonate clast conglomerates derived from nodules in the mudrocks are deposited (draped) onto the erosional surface (b). The conglomerate is overlain by basal sand units (c) with a massive and/or trough cross-bed internal structure. If these units are then subaerially exposed or if overridden by another channel, truncation and erosion occurs. As a result of slack water conditions some mud layers (d) may be deposited delineating the upper and lower bounding surfaces of the in-filling sand bar units. Longitudinal bars then fill the low-relief surface (e). Again, depending on conditions mud may separate the bar surfaces. The remaining accommodation space is then filled with very low relief bars and horizontal planar bed (f). It is in this (f) unit that parting lineations are most likely to occur.

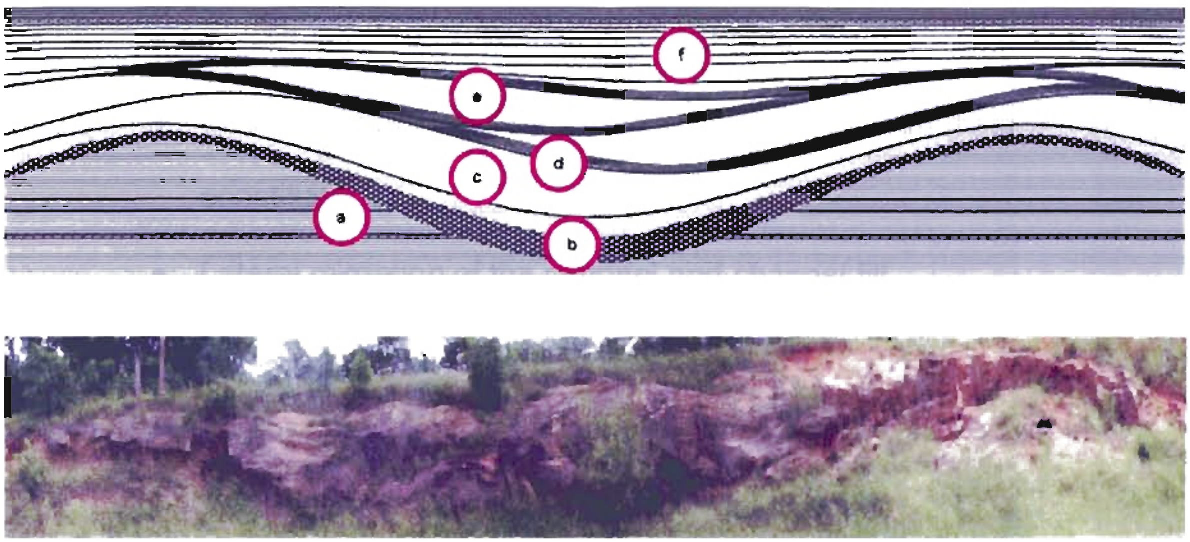


Figure 11. Comparison of an Ideal In-Filling Succession of a Channel with a Garber Outcrop

Sedimentary Structures and Interpretation of Sedimentary Features

Sedimentary structures and bedding styles are the result of sedimentary processes. By observing the type of sedimentary structures and features found in outcrop, a determination can be made as to the processes, and therefore the depositional environment most likely to reflect those characteristics.

Through observation and documentation of the various sedimentary features, lithofacies and lithofacies associations, this study provides evidence that the Garber Sandstone of Cleveland County was deposited within a fluvial paleoenvironment. In addition to the previously mentioned lithofacies, sedimentary features identified within the Garber Sandstone include:

- Scoured / erosive bases of channels
- Crevasse-splay / over-bank deposits
- Stacked and laterally migrating sand bars
- Sediment dominated by sand with mud as a subordinate constituent
- Lateral migration of the channel and channel fill
- Red coloration due to oxidation
- Paleosol development (glaebules, rhizocretions, slickensides)
- Variable but unidirectinal paleo-current direction
- Heterolithic channel fill that fines upward

Within a meandering system, one would expect to find abandoned channels. Figure 12 is a photograph of an outcrop along Hwy 9 which has stacked channel bars and evidence of an abandoned channel. The erosional surface formed as a result of incision is outlined in yellow, Figure 12a. Figure 12b shows the mud cracks that formed on that erosional surface. These mud cracks along with the in-fill of mud rather than sand, suggest the channel was abandoned soon after incision which may provide evidence of an ephemeral system.

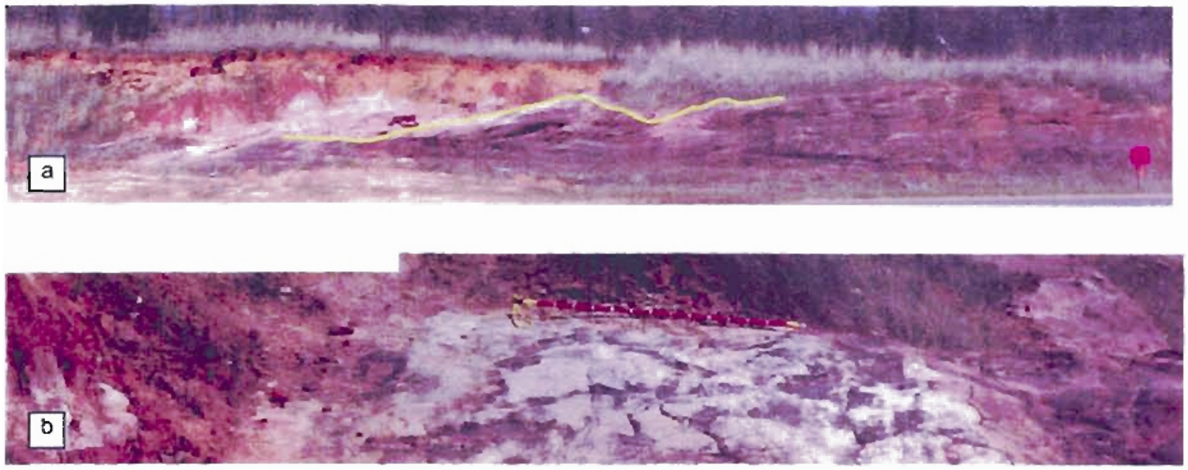


Figure 12. Stacked Channels with Evidence of an Abandoned Channel.
12a – stacked channel sand bars with erosional surface lined in yellow.
12b – mud cracks on erosional surface.

An excellent example of crevasse-splay fan deposits is found on Rock Creek Road, Figure 13. This study interprets these deposits as forming as a result of the adjacent drainage system spilling out into an abandoned channel. Ripples are the dominate lithofacies and the rippled sandstone beds are overlain by mudrock. Crevasse-splays are common to meandering systems.

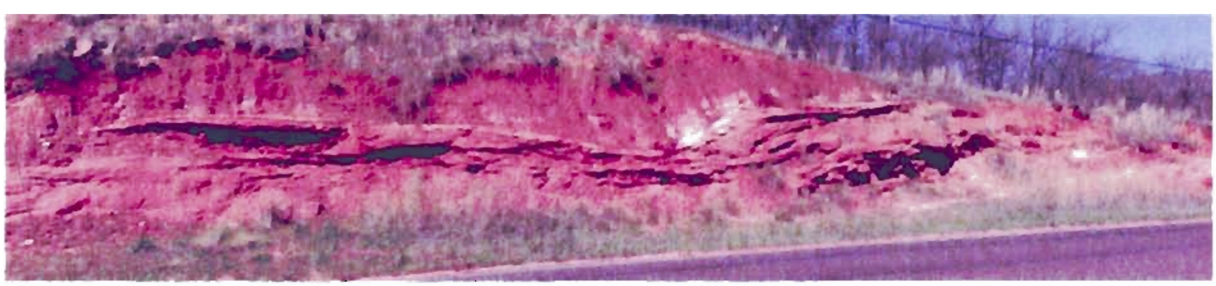


Figure 13. Crevasse-Splay Deposit.

Within a meandering system, channel sand bars migrate as the channel migrates. Shallow laterally migrating point bars can be seen at the base of an outcrop near Indian Point Visitors Center on Alameda Road, Figure 14. The lateral accretion surfaces are highlighted in yellow. Developing over and incising into the older laterally accreted bars are two to three chutes. This photograph has been compressed to fit the page and as a consequence is slightly distorted.

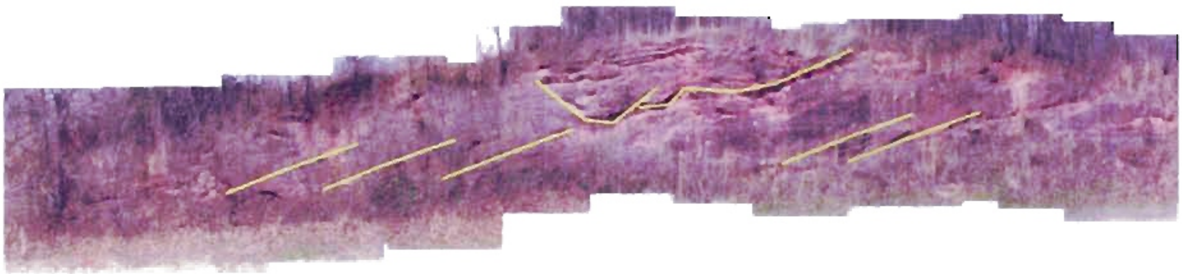


Figure 14. Lateral Accretion Surface of Migrating Channel Sand Bars.

A large outcrop on SE 104th St, just east of 120th Ave (Choctaw Road) (Figure 15) clearly illustrates lateral lithofacies changes. To the right is the channel axis dominated by thick massive sand bars and in the lower right hand corner part of an erosive base can be seen. Toward the left is the channel margin. The channel margin has thinner beds with erosive bases and the presence of ripple lamina. The channel margin also transitions into being dominated by silt and mud sized particles as would be expected in a meandering system.

Figure 15. Outcrop Illustrating Lateral LithofaciesChange

Lateral facies change canalso be seen on an outcrop along Alameda road (Figure 16). Figure 16a is the western end of the outcrop while 16b shows the eastern. Due to space constraints this outcrop has been divided into two photographs. A lateral lithofacies change from sand into silt and mud exists where the sandstone pinches out The yellow arrows are pointing to the channel's margin termination.

Figure 16. Channel Margins with Lateral Lithofacies Change.

On the south side of Stella Road east of 120th Ave., there is a large outcrop that provides another excellent example of lateral channel migration. The sandstone channel delineated by yellow is truncated by an overlying fluvial system while its erosive base incises into the underlying sandstone channel. The lateral channel migration is to the right (west).

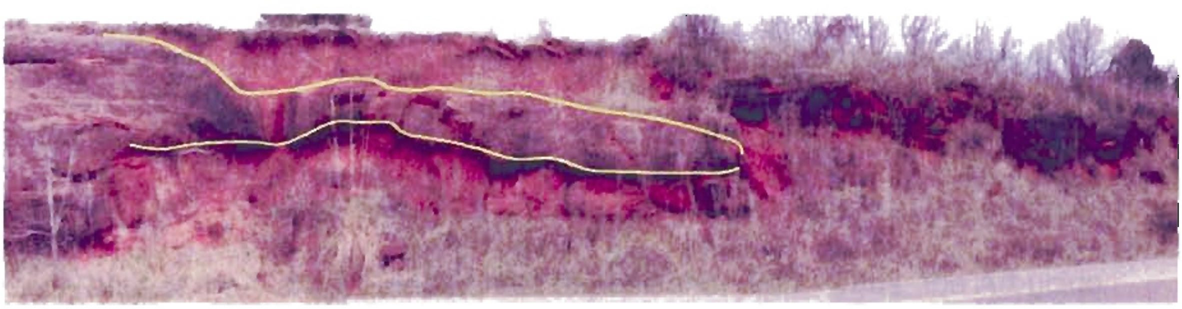


Figure 17. Channel Migration

Sedimentary features and lithofacies associations commonly found in marine and deltaic systems were not observed in Cleveland County but rather the sedimentary features found indicate the Garber Sandstone is most likely a dominantly meandering fluvial system. Additionally, the presence of planar thin beds and lamina frequently seen toward the top of the Garber Sandstone outcrops indicate streaming or supercritical flow energy. Such upper flow regimes may have been produced by flashy flood events or a shallowing of water as accommodation space diminished as a consequence of the channel filling with sediment.

Paleocurrent Analysis

This study has found paleocurrent indicators in multiple directions within the Garber Sandstone. Figure 21 illustrates the paleocurrent directions found at various locations within the transect area. Directional current indicators such as channel cuts with a dip can be used in determining the provenance. The directional current indicators within this study point predominately to the north and northwest with one pointing to the south. The dominance of a north northwest current direction would indicate the provenance was from the south and southeast. Tanner (1959) determined the Garber Sandstone to have one provenance, the Ouachita Mountains. However the geographic location of the Arbuckle Uplift (Upper Pennsylvanian and Lower Permian) is to the south and south east of the Garber Sandstone's depositional area. Thus, the Arbuckle Uplift may have been the probable provenance. Bidirectional paleocurrent indicators such as parting lineations can not be used toward determining the provenance. However, their directional variability or consistency can help determine the depositional environment. Within this study the bidirectional indicator results are variable thus providing evidence of a fluvial system.

Another consideration is the possible impact of a monsoonal climate upon sediment transport. Studies by Lang et al. (2003) indicate that channels within an arid or monsoonal environment experience highly variable and unrelated discharge events. These unrelated discharge events result from extensive and spatially dispersed catchments. Though the geologic history combined with the evidence provided through paleocurrent analysis implicates the Arbuckle Uplift as a likely provenance, Lang's et al. (2003) studies along with the one directional paleocurrent indicator pointing to the south presents the question, is it possible that other catchments to the north and east contributed to the Garber Sandstone's development?

Because of the regional dip, the older Garber units exist to the east, becoming younger toward the west. In an effort to better recognize changes within the Garber Sandstone, more defined time delineations were desirable. Using well log data, Abbott (2005) interpreted the Garber Sandstone to contain three distinct sandstone units or members. He also calculated the regional dip in the Norman area to be 30' / mile. These three sandstone units were used to reflect relative time divisions and using a dip of 30' / mile, each unit thickness was projected to the surface thus dividing the study area into three zones representing time sequences: the oldest (east) to youngest (west). The zones have been superimposed onto Figures 20 through 23.

DEM Stretch Map

Figure 18 is a DEM stretch map for the area south of Lake Thunderbird. This map illustrates the subtle changes in topography that are dependent upon the sub-surface bedrock's erosive character; the dark areas being flat and the white areas having high local slope. (Belt and Paxton, 2005)

The DEM stretch map was used as a guide to evaluate and compare the changes seen on the map to the presence and nature of sandstone outcrops over the southern portion of Cleveland County. This was done by driving the area (outlined in white) in a grid fashion crossing in and out of the changes seen on the map and observing similarities and difference in topography that might reflect differences specific to distribution and character of the local sandstone bodies. The goal was to see if the DEM stretch map reflected lithofacies changes and if so, could it possibly be used as a regional lithofacies base map of the Garber Sandstone.

The area designated as C is the Hennessy Formation and no sandstone outcrops were seen. The topography is mostly flat and dominated by grass lands. According to previous work performed by the USGS, areas A and B are classified as Garber Sandstone. Area A has the greatest relief and though small outcrops also exist within area A, it is only in area A that large outcrops of thick to very thick beds can be found. Area A also displays heavier forestation with the dominate trees being black-jack and post oak. Black-jack and post oak trees prefer well drained sandy soils. The stretch map suggests area A is probably the main depositional fairway or meander belt of this Permian fluvial system.

Furthermore, the geometry as seen on the DEM stretch map indicates the main provenance of the system was to the south and southeast.

Area B is dominated by gently to slightly undulating hills, few scattered small sandstone outcrops with channelized features along with horizontal planar bed / lamina. Area B appears to be an independent regional lithofacies from area A. Area B contains only occasional sandstone outcrops that are relatively much smaller in size and contain predominately planar thin sandstone beds and laminations, thus indicating that this portion of the Garber depositional system had limited accommodation space. Limited accommodation space would have prevented thicker sand bodies from forming and explain the dominance of planar thin beds and laminations. Sparse sandstone units of planar thin beds and lamination between expansive intervals of mudrock indicate that this area was probably an off-axis mud flat adjacent to the main Garber fluvial drainage system.

Baker (1951) preformed a grain size evaluation of the Garber Sandstone sediments over a large part of Cleveland County. His area of study complimented the area evaluated within the DEM stretch map. Reevaluation of the raw grain size data provided by Baker (1951) suggests there is no significant change in grain size from northern Cleveland County to the southern part of the county.

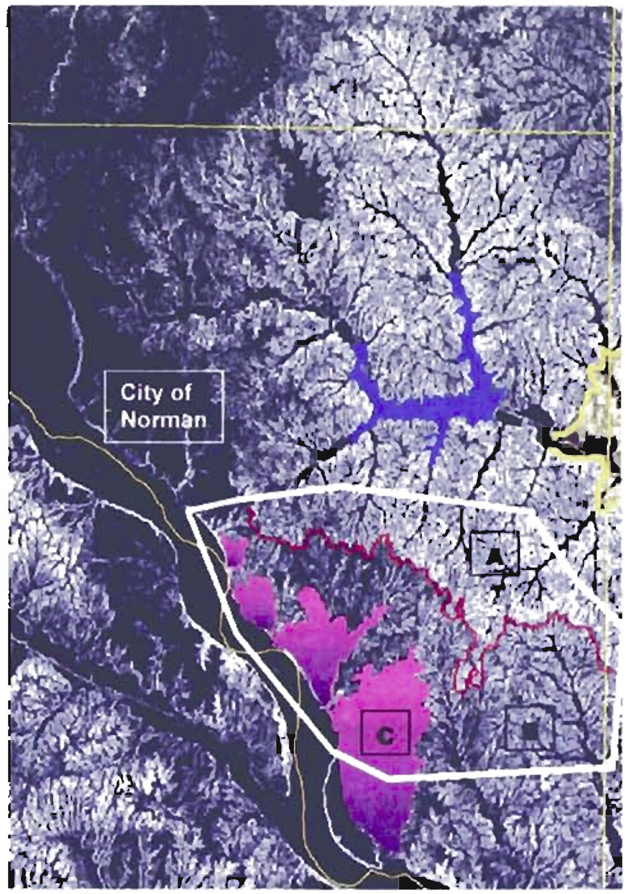


Figure 18. DEM Stretch Map of the Lake Thunderbird Area. Area evaluated designated by bold white border. Area of Wellington outcrop to the east of study is highlighted in yellow and Hennessy to the west is highlighted in pink (C). Area (A) and (B) are Garber Sandstone.

Laboratory Grain Size Evaluation

Grain size variations within a geographic region are generally controlled by the provenance, transport time / distance, and the hydrodynamic conditions existing at the time of deposition. Thus, the use of grain data and grain size distributions can be used to provide some additional evidence for the depositional environment. The use of grain data and grain size distribution as indicators of depositional environments is common practice (Boggs,2001; Folk, 1974; Reineck and Singh, 1975).

Though grain characteristics such as mineralogy, size, shape, and sorting can be used as indicators, limitations do exist. Grain size data should always be used in combination with other parameters, such as sedimentary structures, bed thickness, and other sedimentary features. As Reineck and Singh (1975) state, the grain-size distribution always provides some information on the general hydrodynamic conditions at the site (and time) of deposition.

Therefore, the grain size of clastic sediments is commonly a measure of the energy of the depositional medium. In general, coarser sediments are found in higher-energy environments and finer sediments in low-energy environments. Grain size analysis was utilized within this study to establish the possibility of varying energy regimes and / or variance of source lands for Permian age sediments within the Cleveland County depositional area; both locally (between outcrops) and regionally.

One feature of a fluvial environment is that grain size is expected to decrease downstream. Thus, it is commonly believed that grains are larger at the headwaters and finer in a downstream direction as one nears the coast. Sternberg (1875) first observed downstream fining of sediments in the Rhine River of Germany. The equation

$$D = D_0 e^{-ax}$$

is known as Sternberg's Relationship and states that the grain diameter (D) in millimeters at any location along a river is a function of the diameter at the headwaters (D_0) and the distance downstream for the headwaters (x). This relationship is analogous to the exponential decay of radioactive isotopes as well as many other natural phenomena. However, Smith (2002) noted that though a large body of work has examined changes in grain size, sorting, and roundness in gravel-bed rivers, very few studies have been conducted on their sand-bed counterparts.

One of the few detailed studies concerning all three textural changes on a sand-bed river was undertaken by Pollack (1959, 1961). He studied a 1000 kilometer segment of the South Canadian River. During a period of low flow, he collected sediment in the Canadian River thalweg near highway bridges at 20 locations. Interestingly, he found that no statistically significant fining trend occurred in the median diameter (ϕ_{50}) within the river segment. In addition, he reported no trend in several other distribution parameters, including sorting (standard deviation) and skewness. In conclusion, he states the type and magnitude of processes operating in the low-water channel are the same regardless of position along the longitudinal profile. Pollack determined that all twenty of his sample sites must represent "deposits of a similar hydraulic environment." Smith (2002) replicated Pollack's work and, in contrast, found subtle but significant downstream fining. He determined several factors influence and control downstream fining; one being the local bedrock. "Site-to-site changes in grain size and sorting could be caused by changes in the type of bank materials (especially sedimentary bedrock exposures) as well as changes in near-channel hill slope."

Breit (1989), as well as this author, have determined Garber sands to be homogeneous with minimal variation in grain size, sorting, or roundness. The lack of variation within the grains makes it difficult to recognize variation within the system. In order to discern differences, this author divided grain size categories into bins with narrow ranges. As previously mentioned, Abbott (2005) interpreted the Garber Sandstone to contain three distinct sandstone units or members. Each of these members was used to represent a relative time sequence and their thicknesses were projected to the surface dividing the study area into three zones representing oldest to youngest units; oldest to the east. In relation to the time lines there is an overall fining of sediments toward the west or as the sediments become younger. The results can be seen in Figures 20 through 22.

When attempting to evaluate grain size populations not only is the grain size determined, but also the sorting. Sorting is a measure of the range of grain sizes and the magnitude of the spread or scatter of these sizes around the mean size. Along with grain size, grain sorting may reflect sedimentation mechanisms and depositional environments of ancient sedimentary rocks. Sorting can be used to derive relative distance from the source area. The greater the time / distance transport, the better sorted the grains thus producing texturally mature sediments. Poor sorting indicates lesser time / distance transport (immature). As an example, poor sorting is common to coarser-grained sediments found in alluvial fans and glacial moraines (Emery, 1955). In modern environments coastal (beach) sands show better sorting than sublittoral marine sands, intertidal flats, and fluvial sands. Dune sand of aeolian origin shows the best sorting (Reineck and Singh, 1975). As a general statement and a rule of reference, poor sorting is commonly exhibited in coarse-grained sediments while better sorting is found in finer grained sediment. However, the sandstones around the Lake Thunderbird area are predominately fine grained but moderately sorted. Therefore, it is inferred by this author that the sediments supplying the Garber Sandstone originated from mineralogically mature sedimentary rocks, thus the fine to very fine grain size, but the time / distance transport was not of sufficient duration to produce texturally mature (well sorted) sediments. Figure 23 reflects the sorting in relation to the time lines within the study area.

Nkoghe-Nze (2002) demonstrated that under microscopic examination inherited quartz overgrowths can be seen in the Garber Sandstone. The term 'inherited' is used because, had the overgrowths formed after deposition and burial, they would be more uniformly distributed. Furthermore, overgrowths formed after deposition and burial would extend onto the surface of neighboring quartz overgrowths creating an interlocking mosaic pattern. As the thin section illustrates in Figure 19, the quartz overgrowths are not uniformly distributed nor do they extend onto or contact neighboring quartz overgrowths. Furthermore, the quartz overgrowths seen in this thin section are rounded indicating abrasion through transport. These qualities seen in the quartz overgrowths implicate the type of source land from which the grains originated; first or second generation.

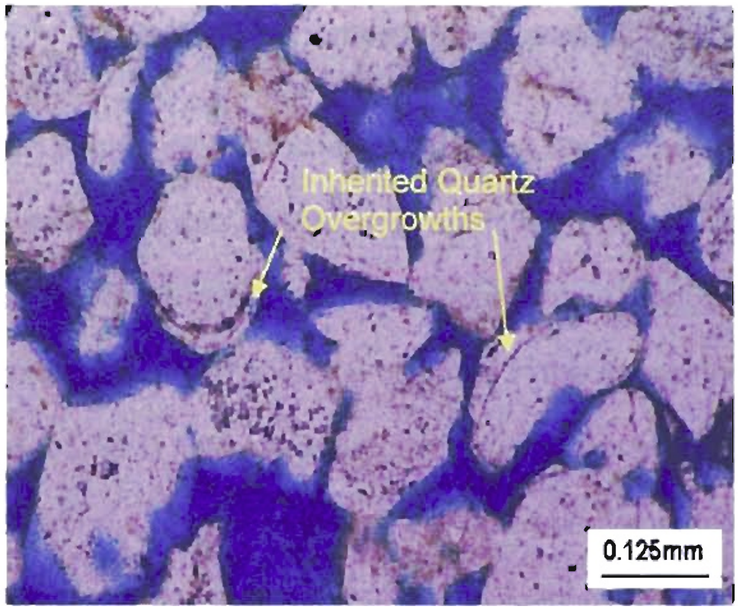


Figure 19. Photomicrograph of Garber Sandstone Sample from Oklahoma County, Oklahoma (Nkoghe-Nze, 2002).

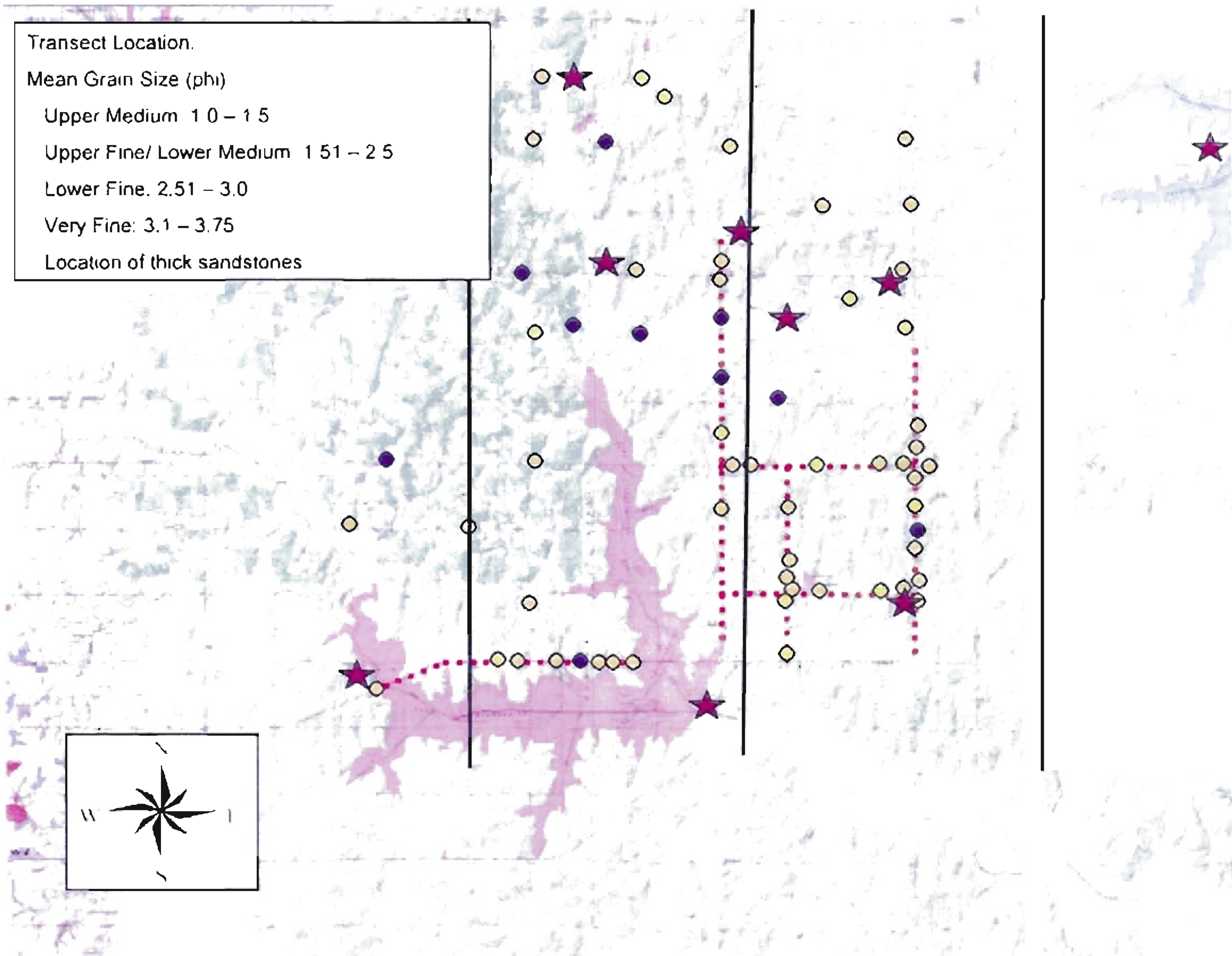
There are two broad classifications of source lands; first and second generation. First generation sediments are commonly derived from igneous and metamorphic terrains and are considered immature relative to time / distance of deposition. Second generation sediments are derived from terrains dominated by sedimentary rocks. Siliciclastic sedimentary rocks by definition are formed from the breakdown of other rocks. Thus, a sedimentary source land is considered mineralogically and texturally mature relative to igneous and metamorphic rocks. The photomicrograph by Nkoghe-Nze (2002) leads to the conclusion that the sand grains sourcing the Garber Sandstone are of second generation. Baker (1951) came to a similar conclusion by studying the heavy minerals. He states, "the major portion of the heavy minerals seem to indicate pre-existing sedimentary rocks as the source of the sandstones."

Paleoenvironment Interpretation

Cox (1978) and Shelton (1973) concluded that the Garber streams terminated as a delta toward an epeiric sea located west-northwest of Cleveland County and the transgressive-regressive cycles of those marine waters along the shallow depositional slope resulted in large lateral changes in the depositional environment. Baker (1951) also concluded the depositional system for the Garber Sandstone to be a shallow inland sea or lake and a sheet like delta. Though mineralogical and sedimentary features indicating a marine environment exist north-northwest of Cleveland County, this study has not found any sedimentary structures or lithofacies associations that definitively provide evidence of a tidal (rhythmic and / or transgressive / regressive cycles) environment for the Garber Sandstone in the Lake Thunderbird vicinity. Furthermore, no strong evidence was observed for a deltaic environment for this study area as suggested by Cox (1978), Shelton (1973), and Baker (1951).

This study provides evidence implicating the location of the Garber Sandstone's main depositional channel or meander belt along with the location of an off-axis mud flat within Cleveland County. In contrast to Tanner (1959), the data gathered in this study provides stronger evidence for a meandering fluvial system rather than a littoral origin for the Garber Sandstone.

Figure 20. Mean Grain Size Distribution Map with Estimated Time Lines.



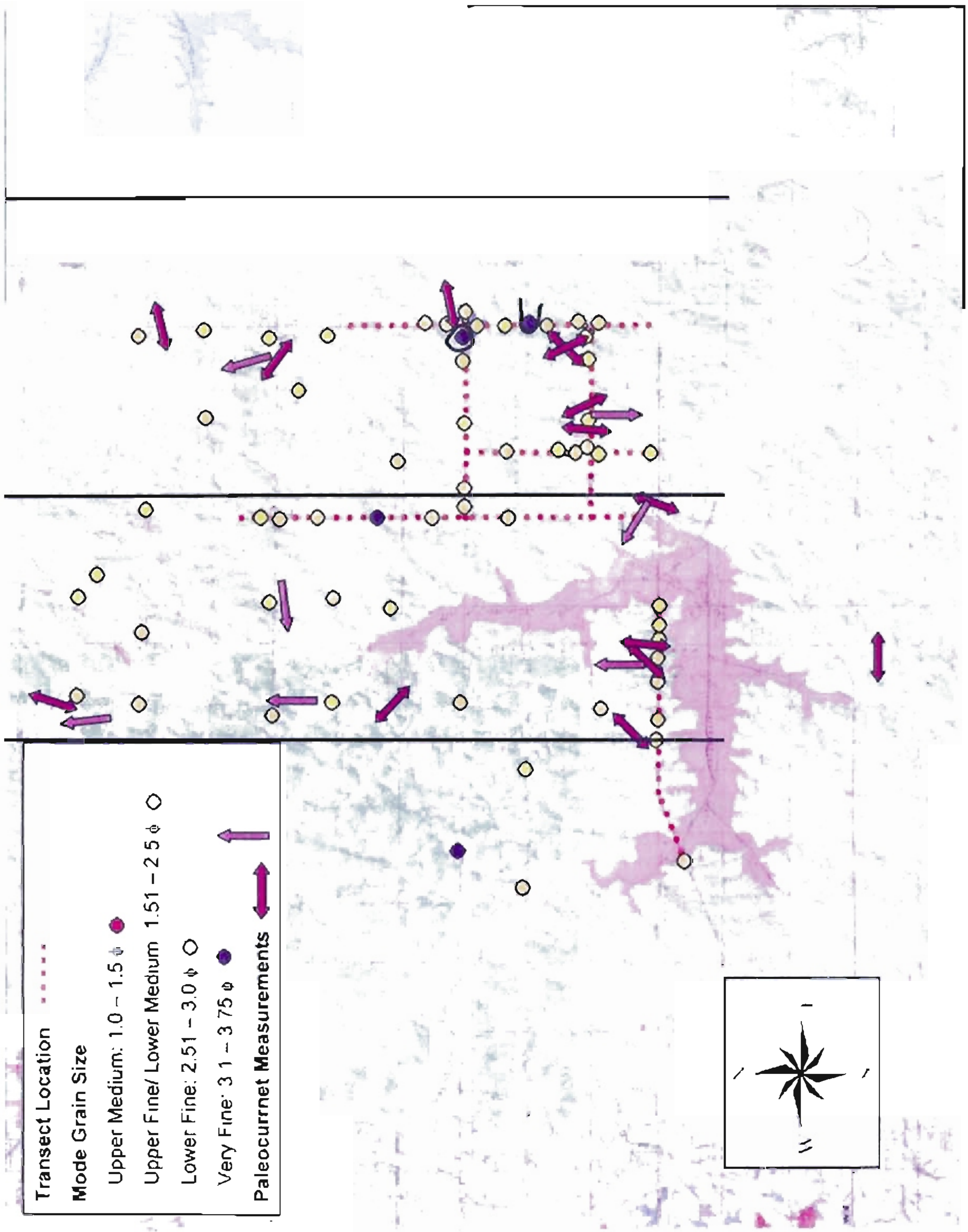


Figure 21. Mode Grain Size Distribution Map wtih Paleo-current Indicators and Estimated Time Lines

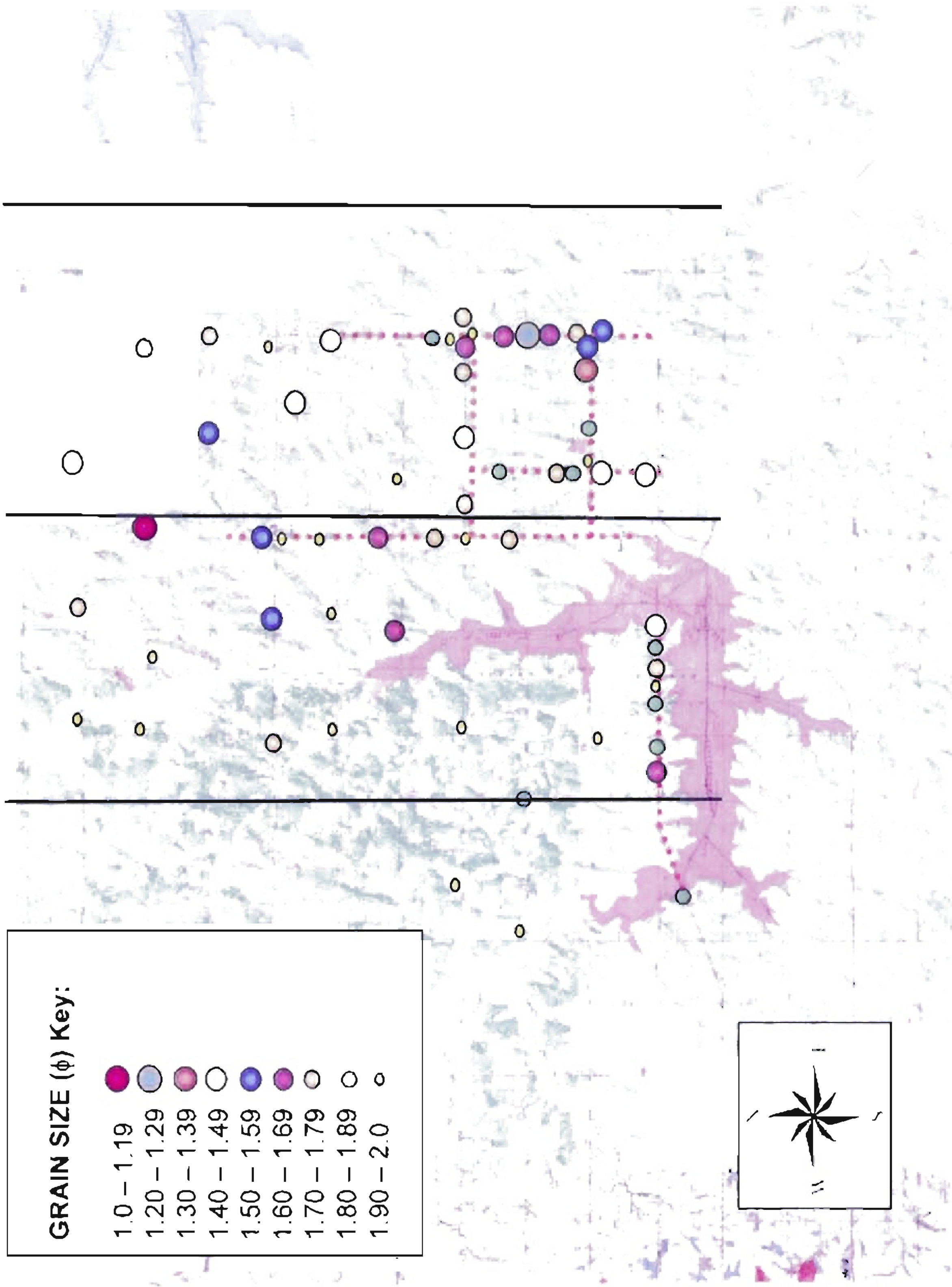


Figure 22. Maximum Grain Size Distribution Map with Estimated Time Lines

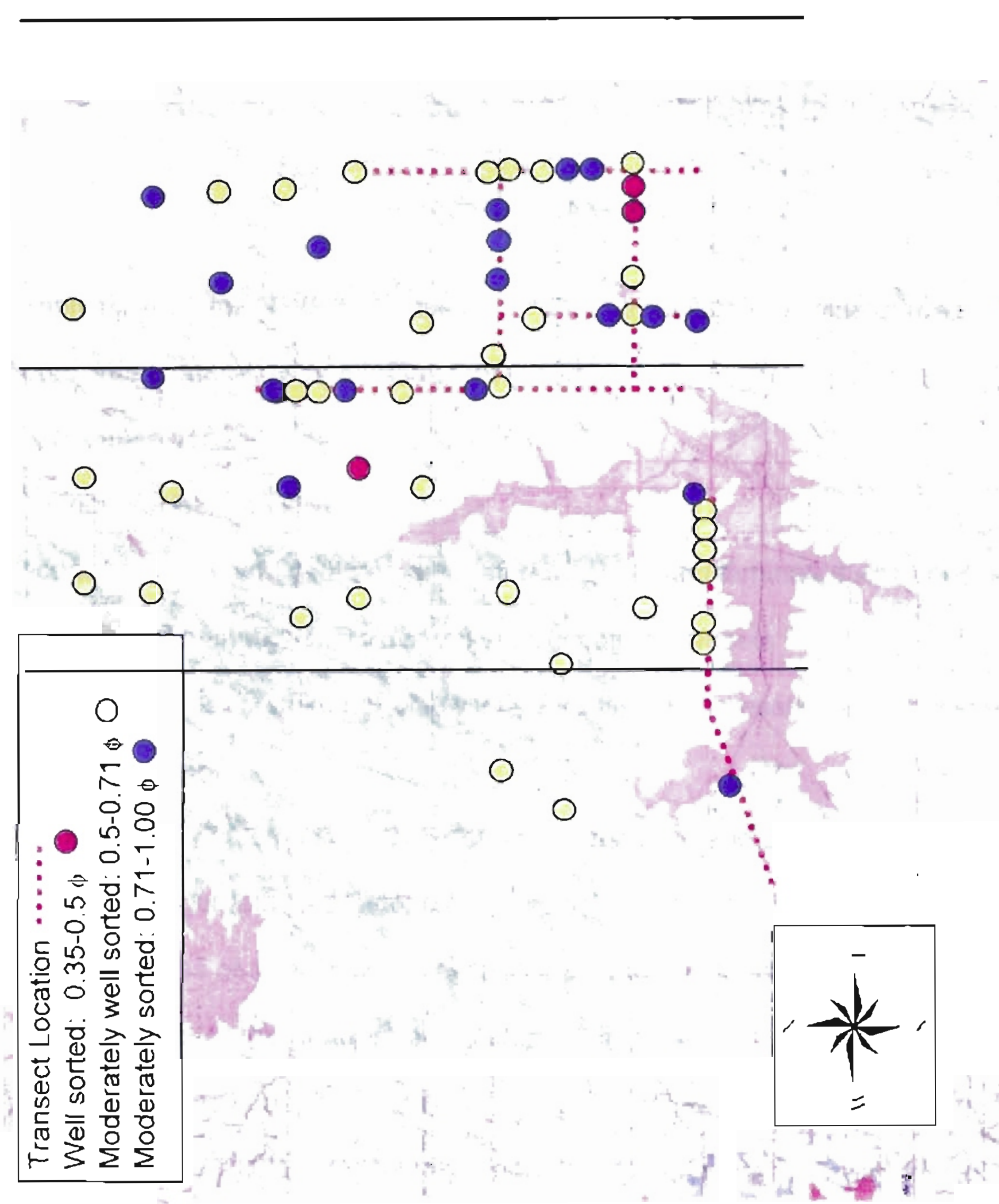


Figure 23 Grain Sorting Distribution Map with Estimated Time Lines

Chapter V

Representative Outcrop for Each Eight Lithofacies

Lithofacies: Massive

Pebbly Road, 6 miles north of Little Axe Park entrance on east side of road

Approximate lateral distance: 382 feet (116m)

Approximate vertical distance: 23 feet (7m)

Dominate facies: massive

Secondary facies and sedimentary features: shale and laminated siltstones, low angle planar laminations, erosive bases, truncation, foresets

Flow direction: 30° (strike-dip of low angle beds); 31° (foresets – possibly small accretionary bars

Summary: This outcrop is on the east side of the road and consists of very thick or amalgamated sandstone units. Erosive bases are common with good examples of truncation. Foresets dipping to the north-northeast are also present. At the northern end of this outcrop the channel margin is well defined with an erosive base down-cutting into the underlying shale and laminated siltstones. The units (bars) build and aggrade toward the south.

Vertical description: location is approximately 286 feet from the north. This is the same vertical section where the gamma ray was obtained by G. Gromadzki.

Base: extends into the subsurface with 17 cm above ground. This sandstone unit has a laminated internal structure and the sand grains are fine, sub-rounded and moderately sorted.

19 cm low angle, mud dominated low angle sandstone laminations dipping to the south but they become more horizontal as one moves vertically. The sand grains are fine, sub-rounded, and poorly sorted.

71 cm unit: massive throughout the basal 42 cm transitioning into very thin beds with foresets dipping to the northeast. The topmost 7 cm is horizontally planar laminated and very thin beds.

Sharp contact: I can not definitively say if this is a very thin shale layer or a contact of differential weathering.

6 meter unit: erosive base with massive internal structure. There are also multiple joints present. The fresh surface color gradates form white throughout the lower half into red for the remainder.

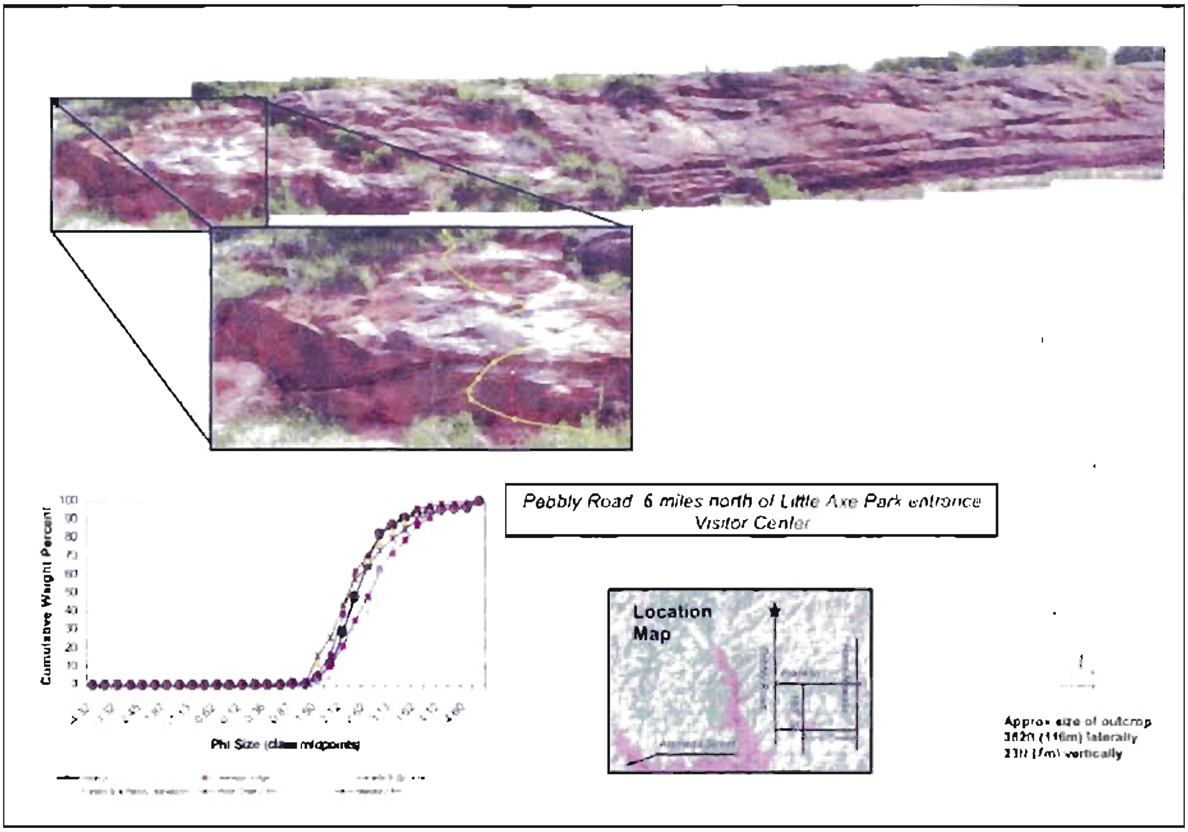


Figure 24. Collective Summary, Pebbly Road, 6 miles north of Little Axe Park entrance

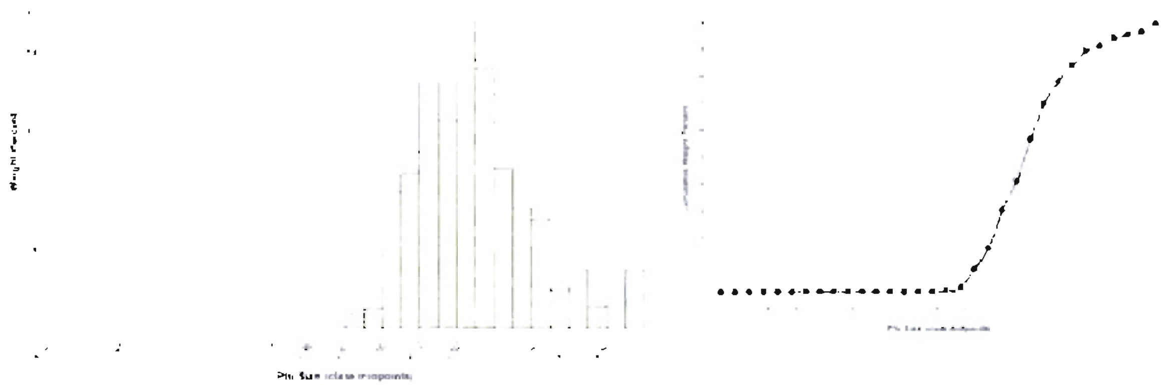


Figure 26. Graphical Representation of Grain Size Data. Pebbly Road 6 miles north of Little Axe Park entrance

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.03	49.45	0.00	-347.71	0.00
0.50	-3.82	0.00	0.00	0.00	-6.53	42.67	0.00	-278.88	0.00
0.50	3.32	0.00	0.00	0.00	-6.03	36.38	0.00	-219.47	0.00
0.49	-2.83	0.00	0.00	0.00	-5.54	30.67	0.00	-169.82	0.00
0.38	-2.45	0.00	0.00	0.00	-5.16	26.64	0.00	-137.52	0.00
0.33	-2.12	0.00	0.00	0.00	-4.83	23.37	0.00	-112.96	0.00
0.25	-1.87	0.00	0.00	0.00	-4.58	21.02	0.00	-96.34	0.00
0.37	-1.50	0.00	0.00	0.00	-4.21	17.72	0.00	-74.60	0.00
0.37	-1.13	0.00	0.00	0.00	-3.84	14.71	0.00	-56.42	0.00
0.25	-0.87	0.00	0.00	0.00	-3.58	12.85	0.00	-46.05	0.00
0.25	-0.62	0.00	0.00	0.00	-3.33	11.10	0.00	-37.00	0.00
0.25	-0.37	0.00	0.00	0.00	-3.08	9.47	0.00	-29.14	0.00
0.25	-0.12	0.00	0.00	0.00	2.83	8.01	0.00	-22.65	0.00
0.24	0.12	0.00	0.00	0.00	2.59	6.72	0.00	-17.43	0.00
0.25	0.38	0.00	0.00	0.00	-2.35	5.50	0.00	-12.91	0.00
0.25	0.62	0.00	0.00	0.00	-2.09	4.38	0.00	-9.18	0.00
0.25	0.87	0.67	0.67	0.58	-1.84	3.39	2.27	-6.24	-4.18
0.25	1.12	0.97	1.64	1.08	1.59	2.54	2.46	-4.04	-3.92
0.38	1.50	6.90	8.54	10.34	-1.21	1.47	10.14	1.78	-12.28
0.38	1.88	7.81	18.35	14.69	-0.83	0.69	5.37	-0.57	-4.46
0.24	2.12	14.07	30.42	29.81	-0.59	0.35	4.92	0.21	-2.91
0.25	2.37	10.52	40.94	24.91	0.34	0.12	1.23	-0.04	-0.42
0.25	2.62	15.77	56.71	41.36	0.09	0.01	0.12	0.00	-0.01
0.25	2.87	13.21	69.92	37.98	0.18	0.03	0.35	0.00	0.06
0.25	3.13	8.07	77.99	25.22	0.42	0.17	1.40	0.07	0.58
0.25	3.38	6.09	84.08	20.58	0.67	0.45	2.73	0.30	1.82
0.24	3.62	5.50	89.58	19.92	0.91	0.83	4.57	0.76	4.17
0.25	3.87	1.90	91.48	7.35	1.16	1.34	2.55	1.55	2.95
0.25	4.12	2.93	94.41	12.07	1.41	1.99	5.82	2.80	8.19
0.24	4.35	1.05	95.46	4.57	1.65	2.71	2.84	4.46	4.68
0.24	4.60	1.29	96.75	5.93	1.89	3.56	4.59	6.71	8.65
0.26	4.86	2.93	99.68	14.24	2.15	4.62	13.53	9.92	29.08
	sum	99.68		270.60			64.68		32.00
		2.76		2.71			0.81		0.61
		Mode		Mean			StandDev		Skewness

Table IV. Method of Moments Chart, Pebbly Road 6 miles north of Little Axe Park entrance

Lithofacies: Ripple Bed / Lamina

Rock Creek Road; 2.6 miles east of Pebbly Road

Dominate facies: Ripple beds and laminations

Secondary facies and sedimentary features: massive, erosive bases, truncation,

Flow direction: west

This is a large outcrop with several distinct divisions. I am presenting the middle portion of the northern outcrop as a representative of rippled laminated lithofacies. However, the outcrop description will be given in its entirety.

Summary: This area is composed of five individual outcrops; two on the north side of the road and three on the south side of the road. On the north side of the road producing the location's topographic high is a channel sand that is situated several meters above the lower but dominate outcrop. I have divided the lower dominate outcrop laterally into three sections based on appearance and physical characterization. The western section (0 – 182 feet measuring from the west) is possibly of stacked and amalgamated sandstone units but it may also be one continuous sand body. The weathering pattern along with the planed surface makes differentiation difficult. The western terminus thins into unconsolidated sediments while the eastern end thins and becomes topographically lower resulting in its top unit becoming the middle section's basal layer. There are ghost planar horizontal laminations throughout.

The middle section (182 – 297 feet measuring from the west) is dominated by thin to medium beds of ripple lamina. The sand grains are medium, rounded, and moderately sorted. As these beds extend vertically, they become slightly wavy in appearance. I have interpreted these units to represent a crevasse splay. There is some minor post-depositional fracturing. These rippled sandstone beds are interbedded with friable laminated upper fine to silt size sands. Many of the sandstone beds have erosive bases along with several areas of truncation.

Vertical description: Location is on the north side of the road at approximately the center of the crevasse-splay

Base: 30 cm thin to bed beds upper fine grained sandstone, red in color. Grains are rounded and moderately sorted

30 cm trough cross-beds, sand grains are upper fine, rounded and moderately sorted, weathered and fresh surface is red

36 cm shale and laminated siltstones

30 cm thin beds with erosive bases, discontinuous high angle and trough cross beds can be seen laterally

30 cm shale and laminated siltstones

20 cm thin to medium sandstone beds of ripple lamina. Grains are fine to very fine, rounded and moderately sorted. Weathered and fresh surface is red in color.

186 cm mudrock

The eastern most section (from 297 – 530 feet measured from the west) is composed of two arched and stacked sandstone units with the topmost unit absent from the apex of the arch eastward.

Vertical description: location is on the north side of the road at approximately 312 feet from the west.

Base: 82 cm unit: massive with the fresh surface being red in color. The sand grains are medium, rounded, and moderately sorted.

48 cm unit: thin beds with fresh surface pink to red in color at the base transitioning into white toward the top. The sand grains are very fine, rounded and moderately sorted.

93 cm of sand rich mudrock

1.7 meter unit: planar horizontal thin to medium beds with a massive internal structure. The sand grains are medium, rounded and moderately sorted.

South side of the road

Summary: Toward the east, the base is dominantly massive units with erosive bases. These units thin vertically into very thin beds of ripple lamina inter-bedded with sand rich mudrock. Overall, these units are dipping to the west – southwest and are possibly aggrading to the west. Toward the western end of the outcrop, producing the location's topographic high, is the continuation of the channel sand previously mentioned which is located on the north side of the road.

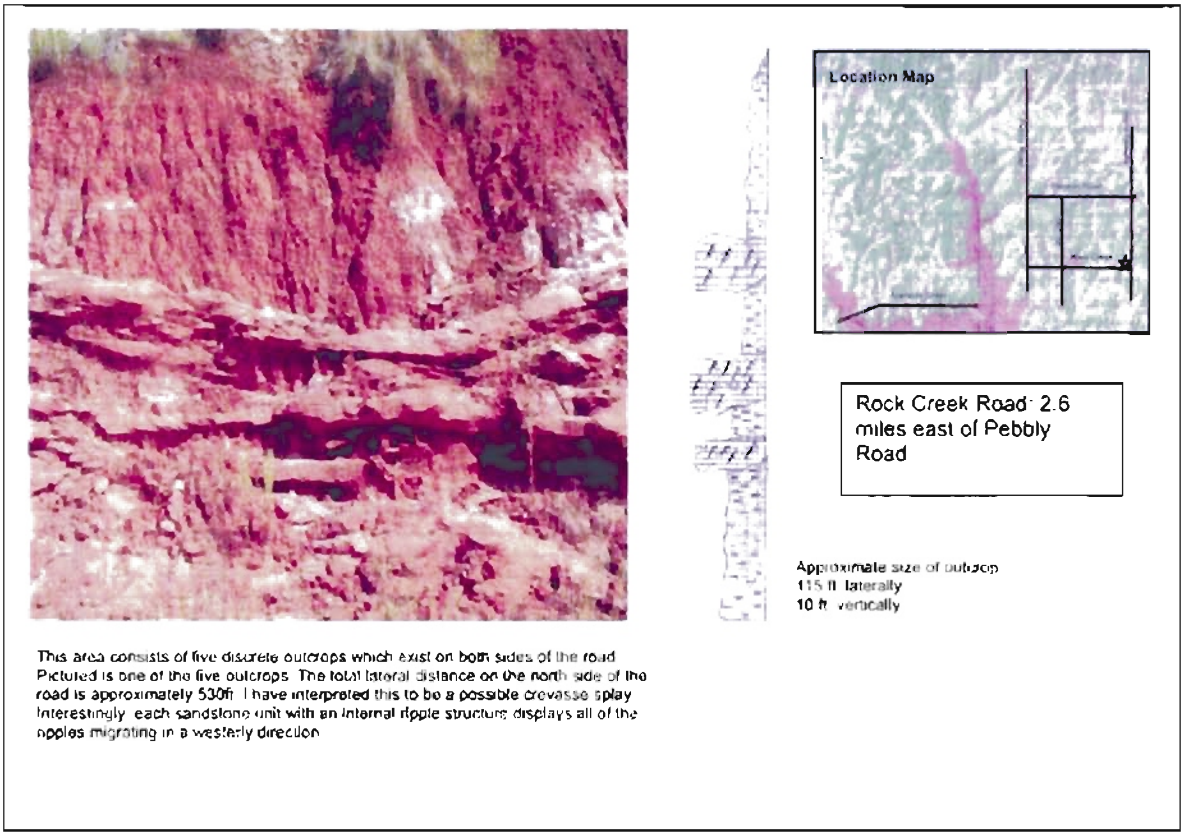


Figure 26. Collective Summary, Rock Creek Road 2.6 miles east of Pebbly intersection

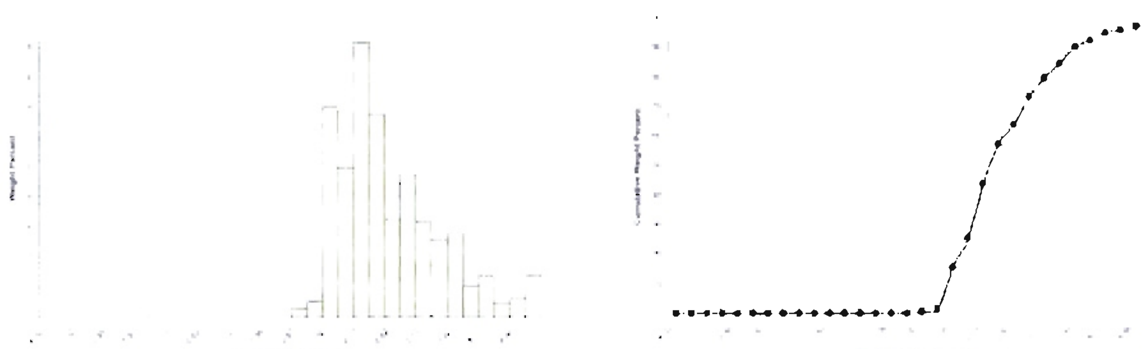


Figure 27. Graphical Representation of Grain Size Data; Rock Creek Road 2.6 miles east of Pebbly intersection

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	*f*		*fm*	*m-x*	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.88	47.36	0.00	-325.93	0.00
0.50	-3.82	0.00	0.00	0.00	-6.38	40.73	0.00	-259.93	0.00
0.50	-3.32	0.00	0.00	0.00	-5.88	34.60	0.00	-203.50	0.00
0.49	-2.83	0.00	0.00	0.00	5.39	29.03	0.00	-156.39	0.00
0.38	-2.45	0.00	0.00	0.00	-5.01	25.12	0.00	-125.88	0.00
0.33	-2.12	0.00	0.00	0.00	-4.68	21.94	0.00	-102.76	0.00
0.25	-1.87	0.00	0.00	0.00	-4.43	19.66	0.00	-87.19	0.00
0.37	-1.50	0.00	0.00	0.00	-4.06	16.48	0.00	-66.91	0.00
0.37	-1.13	0.00	0.00	0.00	-3.69	13.58	0.00	-50.06	0.00
0.25	-0.87	0.00	0.00	0.00	-3.43	11.79	0.00	-40.50	0.00
0.25	-0.62	0.00	0.00	0.00	-3.18	10.13	0.00	-32.22	0.00
0.25	-0.37	0.00	0.00	0.00	-2.93	8.57	0.00	-25.08	0.00
0.25	-0.12	0.00	0.00	0.00	-2.68	7.18	0.00	-19.24	0.00
0.24	0.12	0.00	0.00	0.00	-2.44	5.97	0.00	-14.58	0.00
0.25	0.36	0.00	0.00	0.00	-2.20	4.82	0.00	-10.59	0.00
0.25	0.62	0.00	0.00	0.00	-1.94	3.78	0.00	-7.35	0.00
0.25	0.87	0.54	0.54	0.47	-1.69	2.86	1.55	-4.84	-2.61
0.25	1.12	0.99	1.53	1.11	-1.44	2.08	2.06	-3.00	-2.97
0.38	1.50	14.02	15.55	21.00	-1.06	1.13	15.82	-1.20	-16.80
0.38	1.88	9.95	25.50	18.71	-0.68	0.46	4.59	-0.31	-3.12
0.24	2.12	18.36	43.86	38.90	-0.44	0.19	3.57	-0.09	-1.58
0.25	2.37	13.49	57.35	31.94	-0.19	0.04	0.50	-0.01	0.10
0.25	2.62	6.46	63.81	16.94	0.06	0.00	0.03	0.00	0.00
0.25	2.87	9.49	73.30	27.27	0.31	0.10	0.93	0.03	0.29
0.25	3.13	6.33	79.83	19.79	0.57	0.32	2.03	0.18	1.15
0.25	3.38	5.12	84.75	17.30	0.82	0.67	3.43	0.55	2.81
0.24	3.62	5.60	90.35	20.28	1.06	1.13	6.31	1.20	6.70
0.25	3.87	2.04	92.39	7.89	1.31	1.71	3.49	2.24	4.57
0.25	4.12	2.76	95.15	11.37	1.56	2.43	6.71	3.79	10.46
0.24	4.36	0.91	96.06	3.96	1.80	3.23	2.93	5.79	5.27
0.24	4.60	1.21	97.27	5.56	2.04	4.14	5.02	8.44	10.21
0.26	4.86	2.73	100.00	13.28	2.30	5.29	14.43	12.15	33.17
	sum	**100.00**		**265.76**			73.39		**47.45**
		2.24		**2.56**			**0.861**		**0.75**
		Mode		***Mean***			***StandDev***		***Skewness***

Table V. Method of Moments Chart, Rock Creek Road 2.6 miles east of Pebbly intersection

Lithofacies: Horizontal to Low Angle Planar Thin Beds and Lamina

Franklin Street at Pebbly intersection

Approximate lateral distance: 338 feet (103m)

Approximate vertical distance: 4 feet (1.3m)

Dominate facies: horizontal and low angle planar thin beds and lamina

Secondary facies and sedimentary features: ripple lamina, massive, erosive bases

Flow direction: northwest; parting lineations of 300°

Summary: This outcrop is on the north side of the road. To the west, it thins and becomes discontinuous, completely terminating at the intersection with Pebbly Road. The lateral distance stated above reflects the sandstones that are continuous in nature. It does not include the discontinuous sand units. This outcrop is of both amalgamated sand units and discrete stacked sand units which are separated both vertically and laterally by unconsolidated sediments. This outcrop is dominated by planar thin beds and lamina. Also present, but to a much lesser degree, are ripple lamina. The sand grains are predominately fine to very fine, well rounded (occasionally sub-rounded), and mostly well sorted. The eastern end of this outcrop becomes blocky and thins into unconsolidated sediments. At approximately 148 feet as measured from the west, planar laminations are draped over a topographic high; possibly over-bank deposits.

Vertical description: location is approximately 31 feet from western end of the continuous sand units.

Base: 44 cm unit that is massive with discontinuous ghost planar laminations. It extends into the subsurface and floors the drainage ditch. The weathered surface is black in color while the fresh surface is red in color. The sand grains are fine, well rounded to slightly sub-rounded, and moderately sorted.

24 cm unit: erosive base and planar laminations. The weathered surface is black in color while the fresh surface is red in color. The grains are very fine, well rounded, and well sorted.

66 cm unit: appears to have been deposited atop the underlying unit in a conformable manner without evidence of erosion. The weathered surface is black in color with minor purple coloration. This unit's strength is somewhat friable. The fresh surface is light red at the base gradating into a buff-pink color toward the top. The internal sedimentary structure reflects a FUS as massive at the base transitioning into thin beds then into laminations. The sand grains are very fine, well rounded, and well sorted.

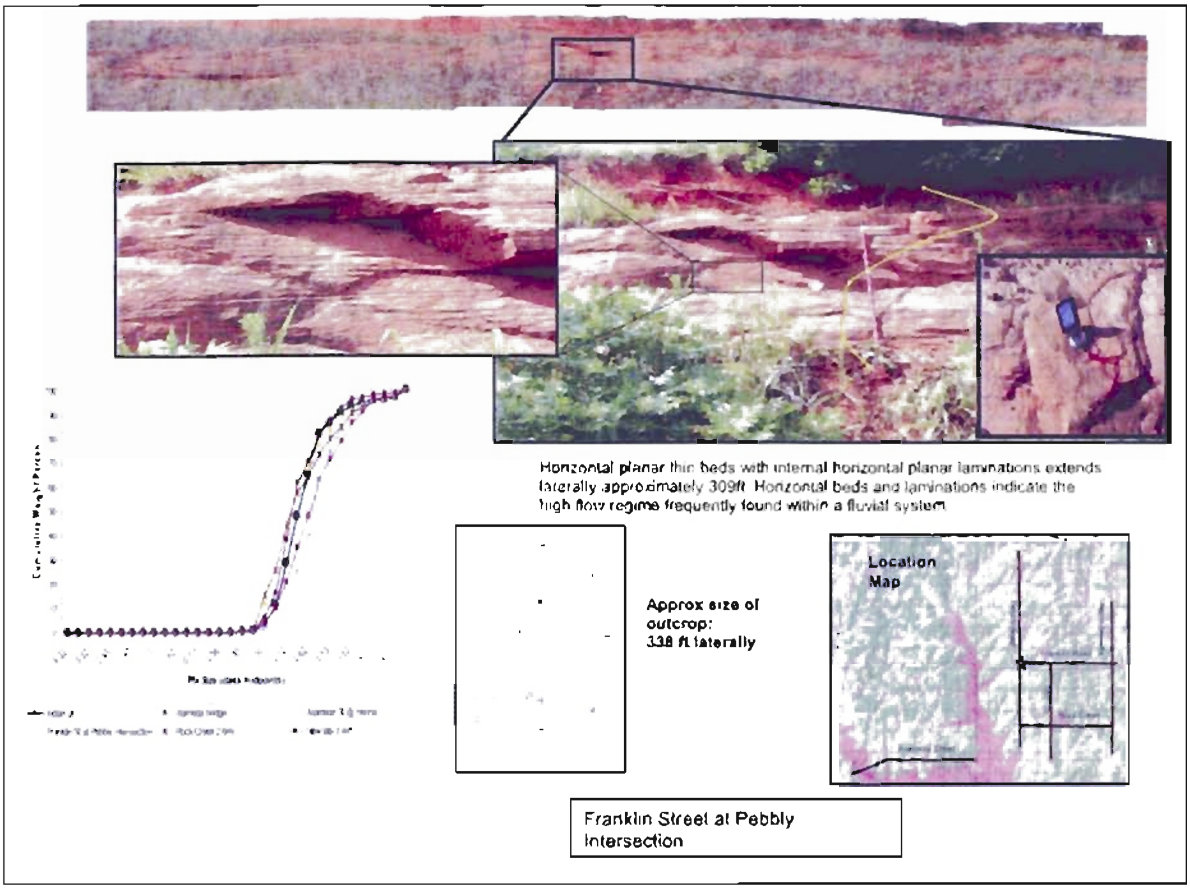


Figure 28. Collective Summary, Franklin Street at Pebbly intersection

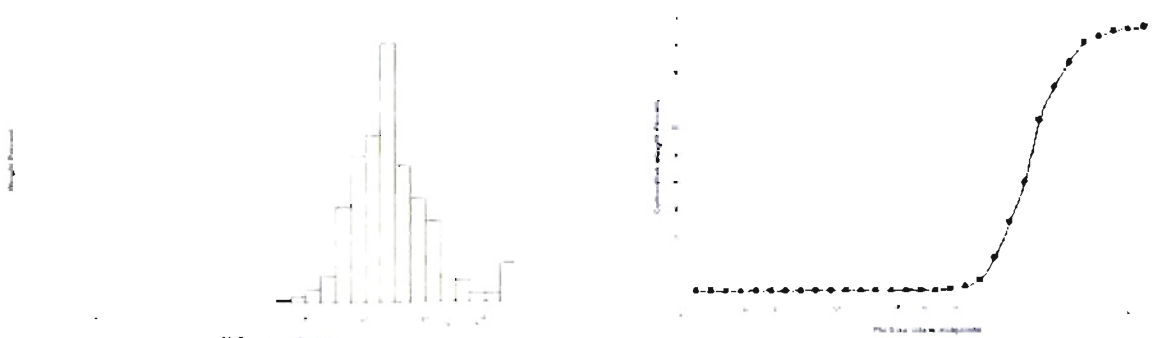


Figure 29. Graphical Interpretation of Grain Size Data, Franklin Street at Pebbly intersection

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.25	52.59	0.00	-381.38	0.00
0.50	-3.82	0.00	0.00	0.00	-6.75	45.59	0.00	-307.81	0.00
0.50	-3.32	0.00	0.00	0.00	-6.25	39.09	0.00	-244.37	0.00
0.49	-2.83	0.00	0.00	0.00	-5.76	33.15	0.00	-190.87	0.00
0.38	-2.45	0.00	0.00	0.00	-5.38	28.96	0.00	-155.86	0.00
0.33	-2.12	0.00	0.00	0.00	-5.05	25.54	0.00	-129.09	0.00
0.25	-1.87	0.00	0.00	0.00	-4.80	23.08	0.00	-110.88	0.00
0.37	-1.50	0.00	0.00	0.00	-4.43	19.62	0.00	-86.92	0.00
0.37	-1.13	0.00	0.00	0.00	-4.06	16.45	0.00	-66.70	0.00
0.25	-0.87	0.00	0.00	0.00	-3.80	14.47	0.00	-55.06	0.00
0.25	0.62	0.00	0.00	0.00	-3.55	12.62	0.00	-44.82	0.00
0.25	-0.37	0.00	0.00	0.00	-3.30	10.87	0.00	35.85	0.00
0.25	-0.12	0.00	0.00	0.00	-3.05	9.30	0.00	-28.35	0.00
0.24	0.12	0.00	0.00	0.00	-2.81	7.91	0.00	-22.25	0.00
0.25	0.36	0.00	0.00	0.00	2.57	6.58	0.00	-16.89	0.00
0.25	0.62	0.00	0.00	0.00	-2.31	5.36	0.00	-12.40	0.00
0.25	0.87	0.10	0.10	0.09	-2.06	4.25	0.42	-8.76	-0.88
0.25	1.12	0.43	0.53	0.48	-1.81	3.29	1.40	-5.96	-2.54
0.38	1.50	1.09	1.61	1.63	-1.43	2.05	2.23	-2.94	-3.19
0.38	1.88	2.24	3.85	4.21	-1.05	1.10	2.46	-1.16	-2.58
0.24	2.12	8.32	12.17	17.63	-0.81	0.66	5.47	-0.53	-4.44
0.25	2.37	12.89	25.06	30.52	-0.56	0.32	4.07	-0.18	-2.29
0.25	2.62	14.63	39.69	38.37	-0.31	0.09	1.38	-0.03	-0.43
0.25	2.87	22.79	62.48	65.48	-0.06	0.00	0.07	0.00	0.00
0.25	3.13	12.07	74.55	37.72	0.20	0.04	0.46	0.01	0.09
0.25	3.38	9.14	83.69	30.89	0.45	0.20	1.84	0.09	0.83
0.24	3.62	7.14	90.83	25.84	0.69	0.48	3.41	0.33	2.36
0.25	3.87	2.24	93.06	8.65	0.94	0.88	1.97	0.83	1.65
0.25	4.12	1.91	94.97	7.85	1.19	1.41	2.70	1.68	3.20
0.24	4.35	0.78	95.76	3.44	1.43	2.03	1.60	2.90	2.28
0.24	4.60	0.79	96.55	3.63	1.67	2.78	2.19	4.62	3.65
0.26	4.86	3.45	100.00	16.78	1.93	3.72	12.85	7.18	24.78
	sum	100.00		283.20			44.64		22.70
		3.00		2.93			0.67		0.76
		Mode		*Mean*			*StandDev*		*Skewness*

Table VI. Method of Moments Chart, Franklin Street at Pebbly intersection

Lithofacies: Trough Cross-beds

Alameda Street; 2.3 miles east of bridge near 120^{th} Avenue

Approximate lateral distance: north side of road – 222 feet (68m) and 320 feet (98 m) western and eastern outcrop respectfully. The south side of the road – 297 feet (91m)

Approximate vertical distance: 10 feet (3 m)

Dominate facies: trough cross beds

Secondary facies and sedimentary features: massive, planar thin beds and lamina, erosive bases

Flow direction: Southwest (foresets)

Summary: At this location, there are two outcrops on the north side of the road. The western outcrop is a blocky continuous sand unit which clearly displays multiple discontinuous 30 to 35 cm bands of trough cross beds. It thins into unconsolidated sands to both the east and west. The apparent apex is approximately 133 feet from the western end. It is capped by approximately 2 feet of unconsolidated sands. Below the base is approximately 10 feet of covered slope.

The eastern outcrop is topographically lower and has been partially planed by the highway department. It is composed of multiple sand units which gradually become blocky toward the east. There is no covered slope below the base of this outcrop.

The southern outcrop has been heavily planed and extends approximately 3 feet vertically and 145 feet laterally. In general, it is massive at the base with ripple lamina, ripple thin beds, planar thin and medium beds toward the top.

Vertical description: Location is within the eastern outcrop 78 feet from the western end. Overall, it has a black weathering surface. All sandstone units are friable unless otherwise indicated.

Base: 57 cm unit with a massive internal structure gradating into lamina throughout the top 21 cm. The fresh surface color is tan. The sand grains are fine, sub-rounded and moderately sorted.

12 cm unit: erosive base and massive internal structure. Due to the weathering pattern and planed surface it is difficult to clearly distinguish if this is not two beds instead of one. However, since it is questionable, I determined it to be one. The sand grains are fine, sub-rounded and moderately sorted.

30 cm unit: laminated internal structure. The fresh surface color is red. The sand grains are very fine, well rounded and well sorted.

120 cm unit: massive. The fresh surface color is white. I question whether this might actually be three units but again can not be definitive. Therefore, I describe it as one based on the consistency of the grains and coloration. The sand grains are very fine to silt, sub-rounded, and moderately sorted. This unit is very friable.

52 cm unit: massive. The fresh surface color is tan to orange. The sand grains are fine to very fine, sub-rounded, and moderately sorted.

24 cm unit: massive. Fresh surface color is gray. Sand grains are fine, sub-rounded, and moderately sorted.

16 cm unit: thin beds gradating into lamina. The fresh surface color is red. The sand grains are fine, sub-angular, and poorly sorted. This unit is firm to slightly friable.

- As previously mentioned, this outcrop becomes blocky toward the eastern end. This blocky area displays erosive bases and undulating thicks and thins with an internal structure reflecting thin to medium cross beds at bases.

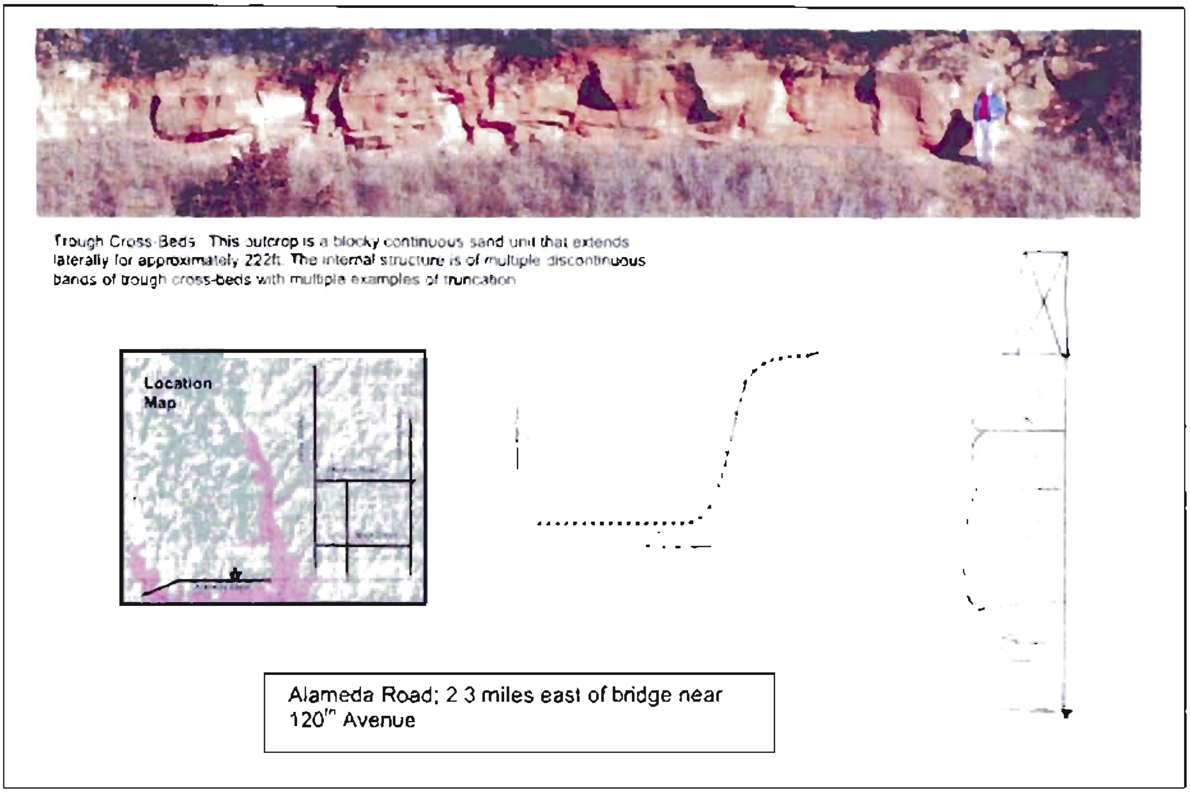


Figure 30. Collective Summary, Alameda Road 2.3 miles east of bridge near 120th Avenue

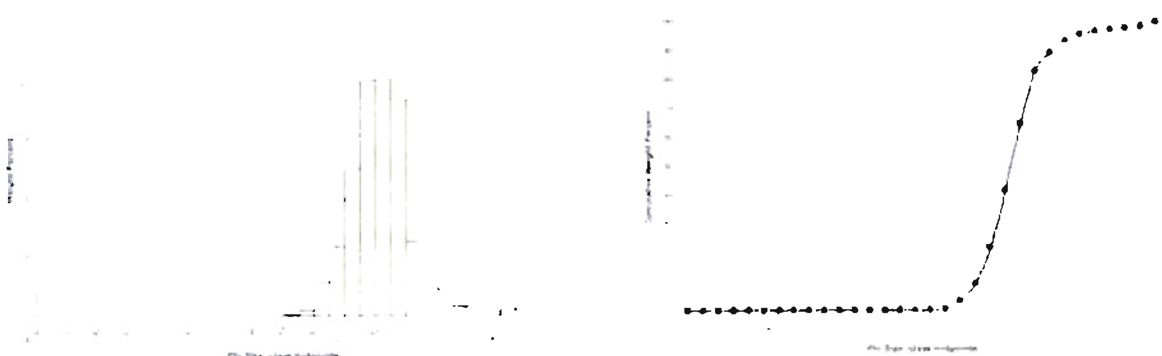


Figure 31. Graphical interpretation of Grain Size Data, Alameda Road 2.3 miles east of bridge near 120th Avenue

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.95	48.33	0.00	-335.98	0.00
0.50	-3.82	0.00	0.00	0.00	-6.45	41.63	0.00	-268.58	0.00
0.50	-3.32	0.00	0.00	0.00	-5.95	35.43	0.00	-210.85	0.00
0.49	-2.83	0.00	0.00	0.00	-5.46	29.79	0.00	-162.56	0.00
0.38	-2.45	0.00	0.00	0.00	-5.08	25.82	0.00	-131.22	0.00
0.33	-2.12	0.00	0.00	0.00	-4.75	22.60	0.00	-107.44	0.00
0.25	-1.87	0.00	0.00	0.00	-4.50	20.29	0.00	-91.38	0.00
0.37	-1.50	0.00	0.00	0.00	-4.13	17.05	0.00	-70.43	0.00
0.37	-1.13	0.00	0.00	0.00	-3.76	14.10	0.00	-52.97	0.00
0.25	-0.87	0.00	0.00	0.00	-3.50	12.28	0.00	-43.03	0.00
0.25	-0.62	0.00	0.00	0.00	-3.25	10.58	0.00	-34.39	0.00
0.25	-0.37	0.00	0.00	0.00	-3.00	8.98	0.00	-26.93	0.00
0.25	-0.12	0.00	0.00	0.00	-2.75	7.58	0.00	-20.78	0.00
0.24	0.12	0.00	0.00	0.00	-2.51	6.31	0.00	-15.87	0.00
0.25	0.36	0.00	0.00	0.00	-2.27	5.13	0.00	-11.63	0.00
0.25	0.62	0.00	0.00	0.00	-2.01	4.06	0.00	-8.17	0.00
0.25	0.87	0.06	0.06	0.05	-1.76	3.10	0.19	-5.47	-0.33
0.25	1.12	0.43	0.49	0.48	-1.51	2.29	0.98	-3.46	-1.49
0.38	1.50	2.81	3.30	4.21	-1.13	1.28	3.60	-1.45	-4.08
0.38	1.88	5.86	9.16	11.02	-0.75	0.56	3.29	-0.42	-2.47
0.24	2.12	12.52	21.68	26.53	-0.51	0.26	3.27	0.13	-1.67
0.25	2.37	20.02	41.70	47.41	-0.26	0.07	1.37	-0.02	-0.36
0.25	2.62	22.89	64.59	60.03	-0.01	0.00	0.00	0.00	0.00
0.25	2.87	18.50	83.09	53.16	0.24	0.06	1.10	0.01	0.27
0.25	3.13	6.29	89.38	19.66	0.50	0.25	1.55	0.12	0.77
0.25	3.38	4.21	93.59	14.23	0.75	0.56	2.36	0.42	1.77
0.24	3.62	2.26	95.85	8.18	0.99	0.98	2.22	0.98	2.20
0.25	3.87	0.79	96.64	3.06	1.24	1.53	1.21	1.90	1.50
0.25	4.12	0.73	97.37	3.01	1.49	2.22	1.62	3.30	2.41
0.24	4.36	0.49	97.86	2.13	1.73	2.98	1.46	5.14	2.52
0.24	4.60	0.49	98.35	2.25	1.97	3.86	1.89	7.60	3.72
0.26	4.86	1.65	100.00	8.02	2.23	4.97	8.20	11.07	18.27
	sum	100.00		263.42			34.31		23.04
		2.75		2.63			0.59		1.16
		Mode		Mean			StandDev		Skewness

Table VII. Method of Moments Chart, Alameda Road 2.3 miles east of bridge near 120th Avenue

Lithofacies: Carbonate Clast Conglomerates

Pebbly Road; 5.2 miles north of Little Axe park entrance

Approximate lateral distance: 100 feet (30.5m)

Approximate vertical distance: 11 feet (3.6m)

Dominate facies: Carbonate clast conglomerate

Secondary facies and sedimentary features: low angle planar lamina, ripple lamina, massive

Summary: This outcrop is on the west side of the road with a drive dissecting its terminal southern end. This drive is a very good place to park. This outcrop exhibits two areas of iron stone with marked differential weathering from the surrounding weakly cemented sandstones. The areas of iron stone are dark purple in color and easily seen. There is also a unit, approximately 1.7 meters thick, at the uppermost area of the outcrop. It is made-up of thin to medium beds of carbonate clast conglomerates. Within the sandstone units are intermittent low angle ghost lamina and ripple lamina. Weathered surface is dominantly black in color.

Vertical description: location is at 52 feet from the south.

Base: 61 cm covered slope

19 cm unit: ripple lamina. The fresh surface is orange to buff in color. The sand grains are fine, rounded, and moderately sorted.

51 cm unit: planar low-angle lamina dipping to the north. Fresh surface color is white. Sand grains are fine, rounded, and moderately-well sorted.

19 cm unit: massive. Fresh surface color is white. Sand grains are fine, rounded, and moderately-well sorted. This unit is separated from the lower unit by differential weathering.

45 cm covered slope consisting of both unconsolidated sediments and finely laminated mud rich siltstones.

1.7 meter unit: thin to medium beds of very strong, well cemented carbonate clast conglomerate.

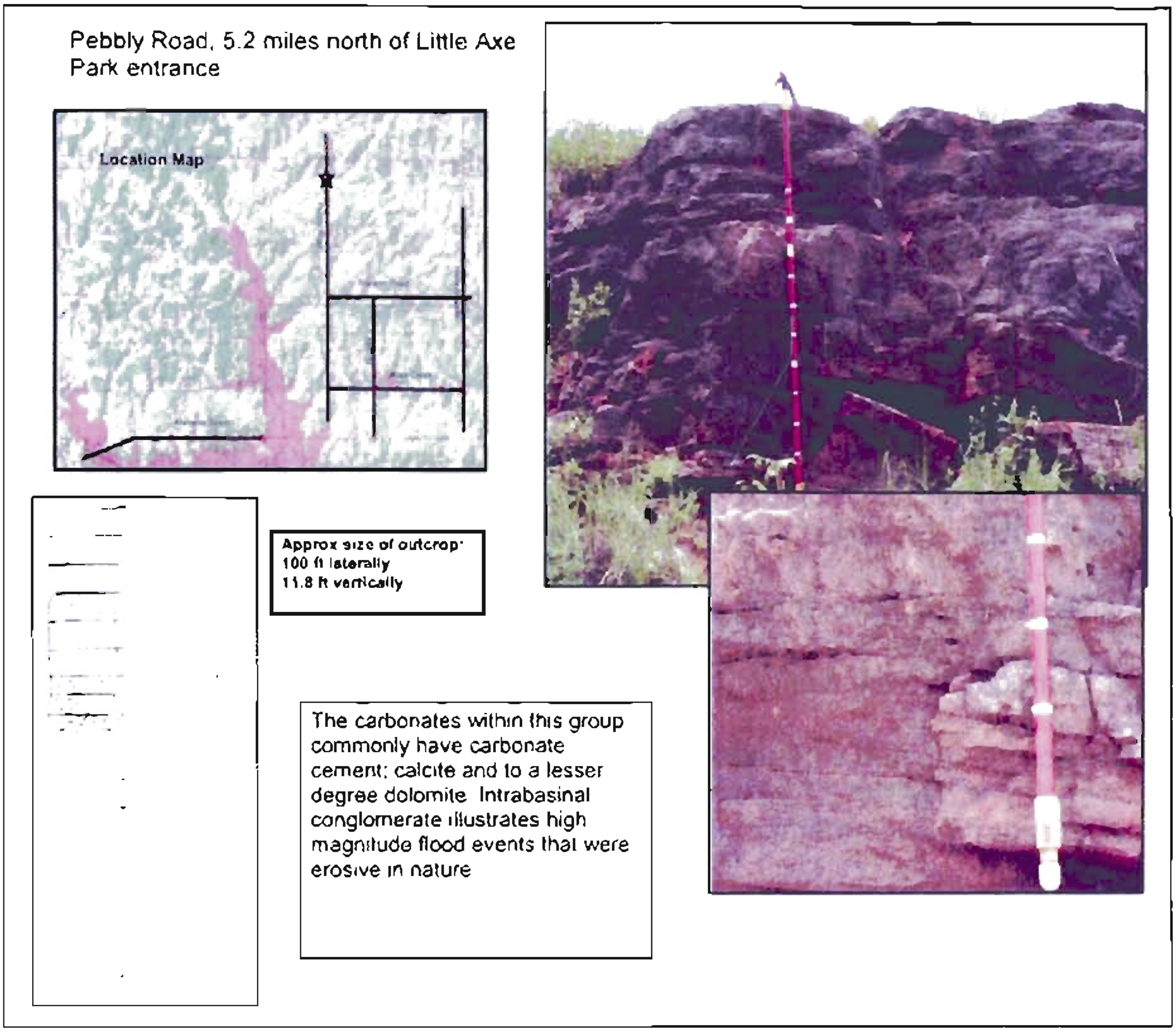


Figure 32. Collective Summary, Pebbly Road 5.2 miles north of Little Axe Park entrance

Lithofacies: Mud-Flake Conglomerate

Western Shore of Lake Thunderbird north of marina

Approximate vertical distance: 6 feet

Sedimentary features present: ripple lamina, low angle horizontal lamination, rip-up clasts, mudflakes (clasts), finely laminated mudstones and siltstones

Flow direction: no indicators noted

Summary: This outcrop has many features indicative of fluvial channels. The underlying mudstones and siltstones are truncated by the overlying erosive base. There are mud rip-up clasts within the basal sands. Within the outcrop, the layers of mud-flake conglomerate can be clearly seen. This outcrop is capped by well cemented conglomerates. Both reflect pencontemperanious intrabasinal formation. The mud-flake conglomerate is unique from the other conglomerate for it is not well cemented and appears to be of only mud-flakes (clasts) whereas the conglomerates capping the outcrop have varying kinds of clasts and are well cemented. Interestingly, one can see where this conglomerate truncated the underlying horizontal planar laminated sandstones.

Vertical description:

Base: 13.5cm of horizontal planar lamina. The grains are fine, rounded and moderately sorted.

0.5 cm: mud

19 cm: planar horizontal laminations with mud rip-up clasts noted. Grains are fine, rounded and moderately sorted

9 cm: massive; weak, non friable. Grains are fine, sub-rounded and moderately sorted

32 cm: thin beds with planar cross beds. Basal rip-up clasts

35 cm: massive with basal rip-up clasts. Moderately strong

18 cm: massive, moderately strong. Grains are fine, sub-rounded and moderately sorted.

19 cm: mudstone

6 cm: mud-flake conglomerate

2 cm: massive; weak, non-friable. Grains are fine, sub-rounded, and moderately sorted.

28 cm: medium beds of very strong conglomerates

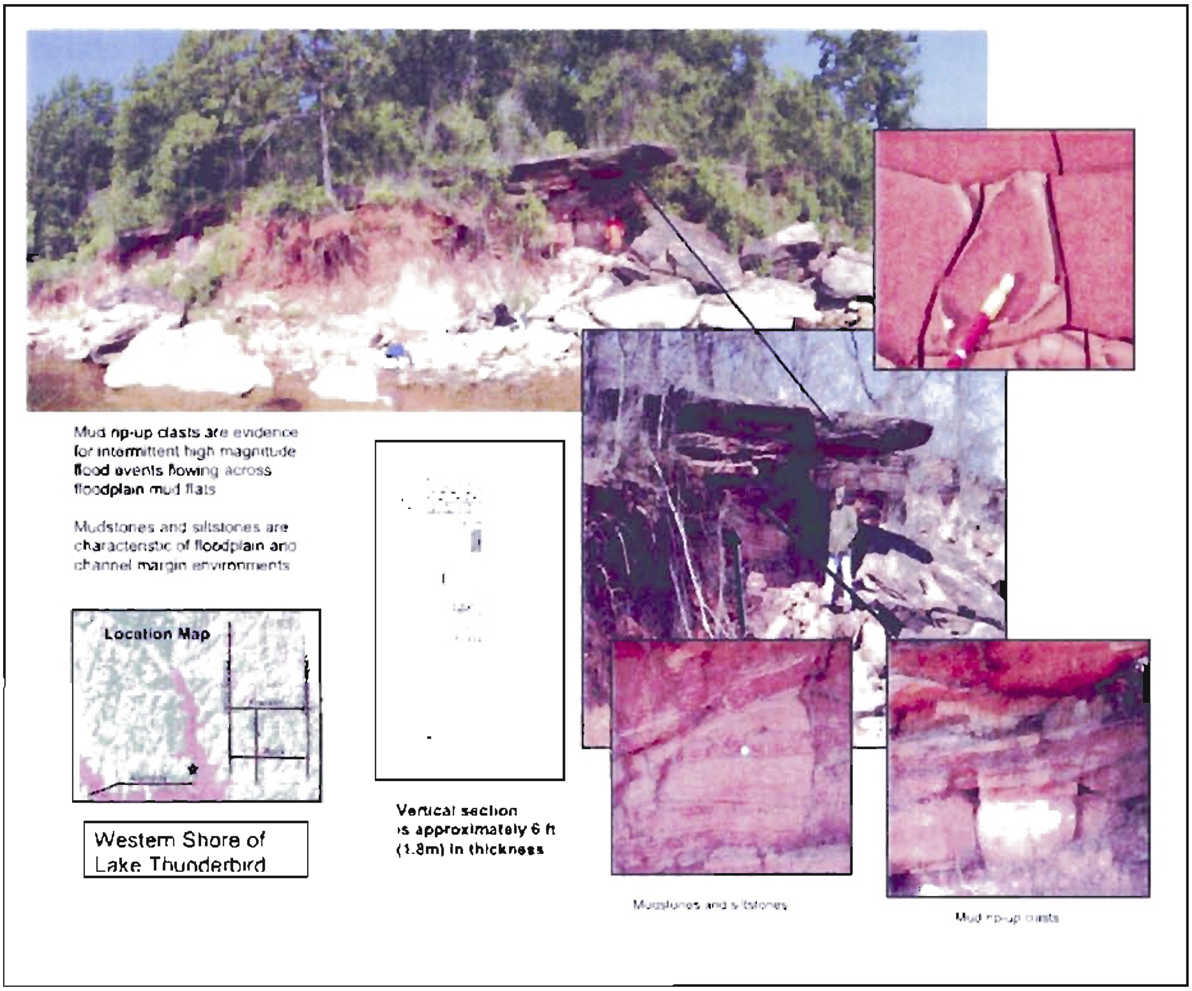


Figure 33. Collective Summary Mud Flake Conglomerate, western shore of Lake Thunderbird

Lithofacies: Mudstone

Pebbly Road; 4.9 miles north of Little Axe park entrance

Approximate lateral distance: 163 (50m) and 303 feet (92m), east and west side of the road respectfully

Approximate vertical distance: East side, north end of the outcrop, 5.4 feet (1.6m)

Dominate facies: mudstone

Secondary facies and sedimentary features present: rippled beds and lamina, carbonate clast conglomerate, shale and laminated siltstones, trough cross beds

Flow direction: 37° (parting lineations) NE (foresets)

Summary: This outcrop exists on both sides of the road. On the eastern side of the road the outcrop is a combination of sandstone units and thin to medium beds of carbonate clast conglomerates. Toward the northern end are approximately seven thin stacked units with possible (poorly defined) trough cross beds. The internal structure of each is dominated by ripple lamina. The top-most unit however is of planar horizontal thin beds with an internal structure of ripple lamina. Also, within the sandstone units are low angle planar laminations and foresets dipping to the northeast along with massive internal structure. Ripple lamina is very prevalent throughout. Within this eastern outcrop there are sandstone units that are gray in color and strongly cemented. They are discontinuous and surrounded by unconsolidated mud rich sand. It should be noted that within my study area, strongly cemented sandstones are the exception rather than the rule. The beds of carbonate clast conglomerates are also discontinuous and vary in thickness of approximately 15 cm to 37 cm. Measuring from the north at approximately 156 feet, a bed of carbonate clast conglomerate, approximately 20 cm thick, exhibits cross-lamination and possibly rippled lamination. Also noted at the southern end at the very top of the outcrop are quartzite and cert gravels and cobbles.

The outcrop on the western side of the road is very weathered and toward the north is dominated by mudstone. Where sandstone exists, it has a planar laminated internal structure with only minor ripple lamina. Truncation and cross-cutting relationships are noted throughout the outcrop. There is a sandstone unit at approximately 149 feet from the south that is strongly cemented and gray in color. The carbonate clast conglomerates on this side of the road are less dominate and more weathered. There is one distinct channel which is downcutting into shale and laminated siltstones of which I interpret as over-bank deposits. The channel trough sandstone is a CUS with an erosive base transitioning from thin into medium beds. The sand grain size is fine, sub-rounded and moderately sorted.

Vertical description: location on the eastern side of the road at approximately 65 feet measured from the north. These are stacked poorly defined but possibly trough cross bedded sandstone units.

Base: Above a covered slope is a 45 cm unit. It has a massive internal structure with discontinuous ripple lamina. The sand grains are upper fine, sub-rounded, and moderately sorted.

76 cm unit: thin beds throughout basal 15 cm then transitioning into massive. Discontinuous rippled lamina is also present. The weathered surface is pink and black in color while the fresh surface color is pink. Sand grains are upper-fine, sub-rounded and moderately sorted.

61 cm unit: mostly massive with ghost ripple lamina throughout. The sand grains are fine, rounded, and moderately sorted.

40 cm unit: ripple laminated. Fresh surface is buff in color. Sand grains are very fine, rounded and moderately-well sorted.

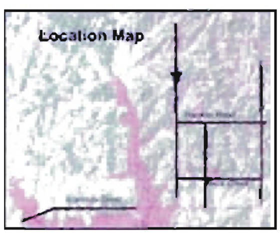
Vertical description: on the west side of the road near the far northern terminus

Approximately 1.5 meters of mudstone. This area is weathered clay sized grains without internal structure. The presence of soil formation indicators found include glaebules, rhizocretions, slickensides, and occasional caliche clasts.

Pebbly Road, 4.9 miles north of Little Axe State Park entrance

The presence of glaebules, rhizocretions, slickensides, along with soil related carbonate deposits, indicate paleosol development

This lithofacies weathers easily and is not common within the study area.



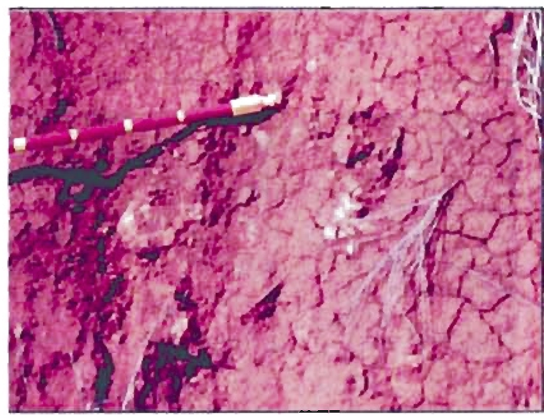


Figure 34. Photo Illustrations of Mudstone Lithofacies

Lithofacies: Shale / Laminated Siltstone

Rather than existing as a dominate lithofacies, the shale / laminated siltstone lithofacies it is present below the erosional base of various channel throughout the study area. This study proposed that the shale / laminated siltstone lithofacies represents flood plain deposits. Quiescent waters may have existed as temporary lakes formed after a flood event. Wind blowing across the water as clay to silt sized particles settled could possibly have produced the lamination seen within this lithofacies.

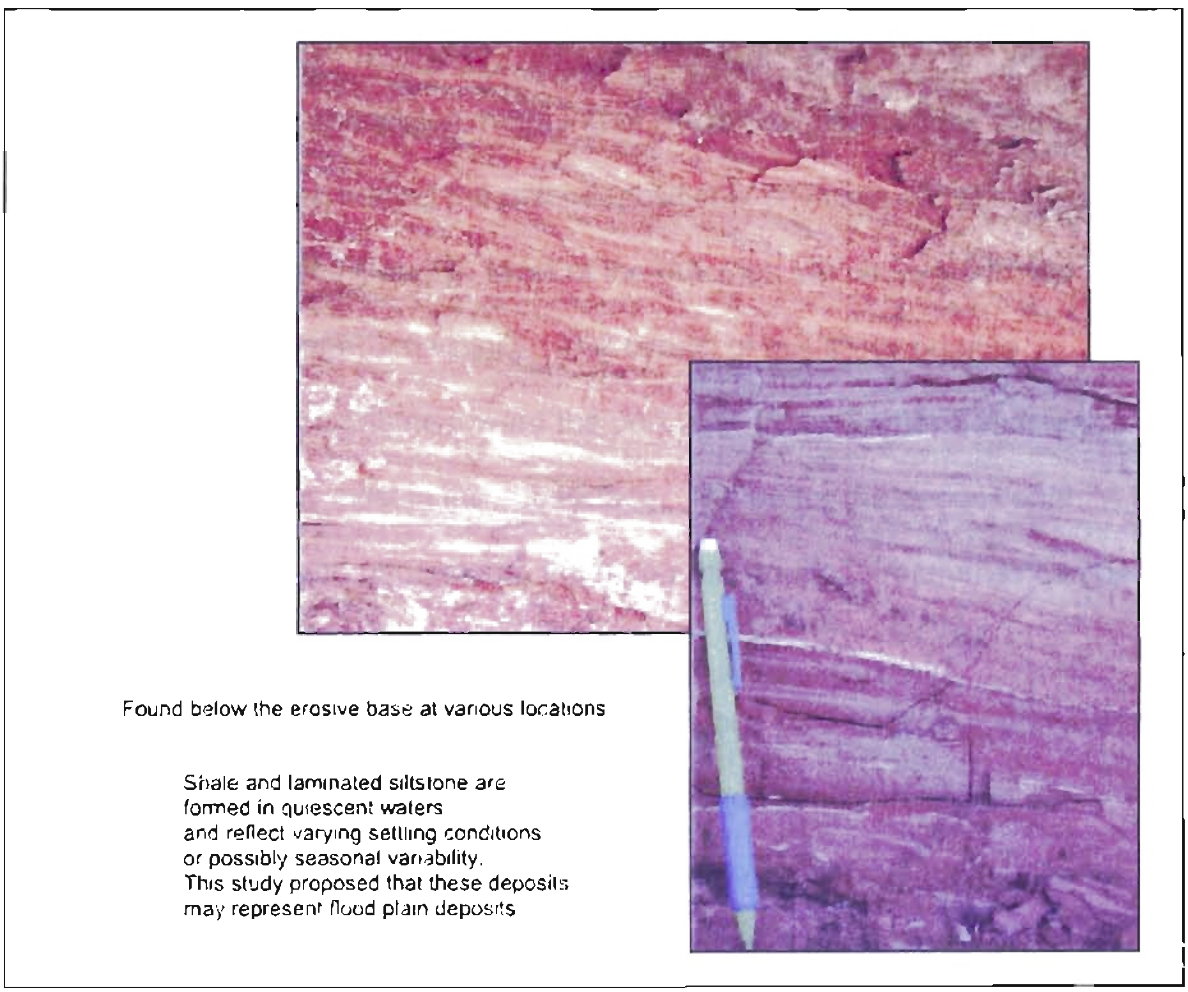


Figure 35. Photo Illustrations of Shale / Laminated Siltstone

Chapter VI

Summary, Recommendations, and Future Work

As a result of the EPA lowering the acceptable maximum level of arsenic in drinking water to 10µg/L, the School of Geology of Oklahoma State University took part in a study of the Garber Sandstone; a formation within the Central Oklahoma Aquifer. The goal of this thesis is to provide detailed outcrop descriptions and documentation, mapping of lithofacies distributions and grain analysis data, and interpreting the paleodepositional environment of the Garber Sandstone in Cleveland County. Most of the outcrops studied were in and around the Lake Thunderbird vicinity. The results of this study provide information that can contribute toward the portrayal of the Garber Sandstone's characteristics as they exist in the subsurface. The better the depositional system is described and understood, the better this aquifer's resources can be managed.

Baker (1951) described the Garber Sandstone as a shallow inland sea or lake. Tanner (1959) interpreted his data as evidence of a littoral origin and concluded that the paleodepositional environments responsible for the Garber Sandstone were fluvial, deltaic, and marginal marine. This study provides evidence in support of a fluvial environment. However, no supporting evidence was found for deltaic, marginal marine, littoral or an inland sea.

This study examined and evaluated several key elements; lithofacies distribution, sedimentary features found in outcrop, paleocurrent indicators, and local and regional grain size variance. As the study progressed, the incorporation of a DEM stretch map was also included in an effort to test the possibility that the topographic relief illustrated by the DEM image correlated with regional changes in lithofacies. The lithofacies classifications and other major findings include:

1. The main lithofacies present within the Garber Sandstone are: 1) thick to very thick massive sands, 2) ripple laminated sandstone of variable thickness, 3) horizontal to low angle planar laminations of variable thickness, 4) tabular and trough cross-beds, 5) carbonate-clast conglomerates, 6) mud-flake conglomerates, 7) mudstones, and 8) shale / laminated siltstones.
2. The Garber Sandstone is the geologic record of depositional processes found within a dominantly meandering fluvial environment. Evidence found in the Garber Sandstone indicating a meandering system include

    - Scoured / erosive bases of channels
    - Crevasse-splay / over-bank deposits
    - Stacked and laterally migrating sand bars
    - Sediment dominated by sand with mud as a subordinate constituent
    - Lateral migration of the channel and channel fill

- No fossils
- Red coloration due to oxidation
- Paleosol development and rooting in flood plain mudstones
- Variable but paleo-current direction
- Heterolithic channel fill that fines upward

3. The provenance of the Garber Sandstone was a mature sedimentary rock environment. Evidence supporting this conclusion is the presence of inherited quartz overgrowth; quartz overgrowths not uniformly distributed nor extending onto or contacting neighboring quartz overgrowths. Furthermore, the sandstones of the Garber Sandstone are quartzarenite and sublitharenite (Breit, 1998) and have minimal variation in grain size; predominately fine and very fine grains, rounded with moderate sorting. Thus the grain size indicates maturity while the sorting indicates texturally less mature sediments. Paleocurrent indicators implicate the Arbuckle uplift as the likely provenance.
4. Within the limited scope of this study, the topographic relief seen on the DEM stretch map image does correlate with lithofacies change. Through the integration of the DEM with the outcrop findings, this study delineated the main depositional channel or meander belt from the off-axis mud flat adjacent to the main Garber fluvial drainage system.

When considering recommendations toward possible future drill sites, one must consider evidence presented in previous research by Schlottmann et al. (1998) and Christenson et al. (1998). Their studies indicate an association between the presence of mudrock and elevated levels of aqueous arsenic in the Central Oklahoma Aquifer. Therefore, in an effort to avoid the presence of high levels of aqueous arsenic, the drilling of water wells should be limited to areas of greater sandstone development. This study recommends the thicker sandstones east of the City of Norman in the region designated as the main channel of the Permian Garber Sandstone as the focus in future drill site evaluations.

Suggested further work involving the Garber Sandstone includes petrographic studies and DEM evaluations. A detailed petrographic study may provide evidence for and clarify the provenance(s) of the Garber Sandstone along with intrabasinal depositional processes and possible paleosol development. The use of a DEM in determining lithofacies changes by observing subtle topographic changes may prove promising for large regional studies. Because of time constraints, the value of a stretch map toward lithofacies evaluation of the Garber was not fully investigated. More evaluation is needed to validate this approach.

REFERENCES

Abbott, B., 2005, Subsurface well-log correlation: Master's Thesis, Oklahoma State University.

Anderson, G.E., 1927, Geology of Cleveland and McClain Counties: Oklahoma Geological Survey Bulletin, no. 40-N, p. 180 – 192.

Aurin, F.L., Officer, H.G., and Gould, C.N., 1926, The subdivision of the Enid Formation: American Association of Petroleum Geologists Bulletin, v. 10, no. 8, p. 786-799.

Baker, F.E., 1951, A mechanical and petrographic analysis of the Garber Sandstone in Cleveland and Pottawatomie Counties: Masters Thesis, University of Oklahoma.

Belt, K. and Paxton, S.T., 2005, GIS as an aid to visualizing and mapping geology and rock properties in regions of subtle topography: GSA Bulletin, v. 117, no. ½, p 1-12.

Breit, George N., 1998, The Diagenetic History of Permian Rocks in the Central Oklahoma Aquifer *in* Christenson, Scott, and Havens, J.S, eds., Ground-Water-Quality Assessment of the Central Oklahoma Aquifer, Oklahoma: Results of Investigations: U.S. Geological Survey Water-Supply Paper 2357-A, p. 45-67.

Boggs, S. Jr. ed., 2001, Principals of sedimentology and stratigraphy, 3rd ed.: Printice-Hall, Inc., New Jersey.

Bouma, A.H., 1962, Sedimentology of some flysch deposits – A graphic approach to facies interpretation. Elsevier, New York.

Cambell, C.V., 1967, Lamina, laminaset, bed and bedset: Sedimentology, v. 8, p. 7-26.

Christenson, S., Parkhurst, D.L., and Breit, G.N., 1998, Summary of geochemical and geohydrologic investigations of the Central Oklahoma aquifer, in Christenson, Scott, and Havens, J.S., eds., Ground-water quality assessment of the Central Oklahoma aquifer, Oklahoma-Results of investigations: U.S. Geological Survey Water-Supply Paper 2357-A, p. 107-117.

Christenson, Scott, 1998, Ground-water-quality assessment of the central Oklahoma aquifer: summary of investigations *in* Christenson, Scott, and Havens, J.S, eds., Ground-water-quality assessment of the Central Oklahoma aquifer: summary of investigations: U.S. Geological Survey Water-Supply Paper 2357-A, p 1-33.

Christenson, S.C., Morton, R.B., and Mesander, B.A., 1992, Hydrogeologic maps of the Central Oklahoma aquifer: U.S. Geological Survey Hydrologic Investigations Atlas HA-724, 3 sheets

Cipriani, D., 1963, General geologic sections of Oklahoma and northern Arkansas: Retrieved in March, 2004 from www.ogs.ou.edu/fossilfuels/typeslogs.php

Collinson, F.D. and Thompson, D.B. eds., 1989, Sedimentary structures, 2nd ed.: Harper Collins Academic, New York.

Compton, R.R., 1985, Geology in the field: John Wiley & Sons, Inc., New Jersey.

Cox, R.E., 1978, Subsurface geochemical exploration of strata-bound copper in lower Permian red beds in north-central Oklahoma: Master's thesis, Oklahoma State University.

Dixon, D, Jenkins, I, Moody, R.T., and Zhuravlev, A.Y., 2001, Atlas of Life on Earth: Andromeda Oxford Limited, Abingdon, Oxfordshire.

Dubiel, R.F., Huntoon, J.E., Condon, S.M., and Stanesco, J.D., 1996, Permian deposystems, paleogeography, and paleoclimate of the Paradox basin and vicinity, *in* Longman, M.W., and Sonnenfeld, M.D., eds., Paleozoic Systems of the Rocky Mountain Region: SEPM, Rocky Mountain Section, p. 427-444.

Dubiel, R.F., Parrish, J.T., Parrish, J.M., and Good, S.C., 1991, The Pangean megamonsoon-Evidence from the Upper Triassic Chinle Formation, Colorado Plateau: .PALAIOS, v.6, p. 347-370.

Emery, K.D., 1955, Grain size of marine beach gravels: Journal of Geology, v. 63, p. 39-49.

Fichter, L.S. and Poché, D.J. eds, 2001, Ancient Environments and the Interpretation of geologic history 3rd ed.: Prentice-Hall, Inc. New Jersey.

Folk, R.L., 1974, Procedures in sedimentary petrology: John Wiley & Sons, New York.

Gough, L.P., Shacklette, H.T., and Case. A.A., 1979, Element concentrations toxic to plants, animals, and man: U.S. Geological Survey Bulletin 1466, p. 80.

Green, D.A., 1937, Major divisions of Permian in Oklahoma and southern Kansas: American Association of Petrolium Geologist, v. 21, no. 12, p. 1515 – 1533.

Gromadzki, G., 2004, Outcrop-based high resolution gamma-ray characterization: Master's Thesis, Oklahoma State University.

Hamblin, W.K., 1965, Internal structures of "homogeneous" sandstones: Kansas Geological Survey Bulletin, no. 175, p. 569-582.

Ingram, R.L., 1954, Terminology for the thickness of stratification and parting units in sedimentary rocks: Gological Society of America Bulletin 65.

Kessler, J., Soreghan., G. and Wacker, H, 2001, Equatorial aridity in western Pangea: Lower Permian loessite and dolomitic paleosols in northeastern New Mexico, U.S.A.: Journal of Sedimentary Research, v. 71, no. 5, p. 817-832.

Klein, C. and Hurlbut, Jr.,1999, Manual of Mineralogy 21ed,: John Wiley & sons, Inc.

Krumbein, W.C., and F.J. Pettijohn, 1938, Manual of sedimentary petrography: Appleton-Century Crofts, New York.

Kutzbach, J.E., and Gallimore, R.G., 1989, Pangean climates: Megamonsoons of the megacontinent: Journal of Geophysical Research, v. 94, p. 3341-3357.

McKee, E.D. and Weir, G.W., 1953, Terminology for stratification and cross-stratification in sedimentary rocks: Geological Society of America Bulletin, v. 64, p. 381-390.

Nairn, A., and Smithwick, M., 1976, Permian paleogeography and climatology, *in* Falke, H., ed., The continental Permian in central, west, and south Europe: Boston, D. Reidel, p. 283-312.

Nkoghe-Nze, S.C., 2002, A reconnaissance study of controls on aquifer quality in the Central Oklahoma Aquifer, Oklahoma: Master's Thesis, Oklahoma State University.

Ogg, Jim, 2004, Overview of global boundary stratotype sections and points (GSSP's): retrieved in November, 2005, from www.stratigraphy.org/gssp.htm

Otto, G.H., 1938, The sedimentation unit and its use in field sampling: Journal of Geology, v. 46, p. 569-582.

Parkhurst, D.L., 1992, The geochemical evolution of ground waters in the Central Oklahoma aquifer [abs.], *in* Christenson, Scottt, and Carpenter, Lyn, eds., 1992, Ground-water quality of the Central Oklahoma (Garber-Wellington) aquifer converence – Proceedings, February 20, 1992: U.S. Geological Survey Open-File Report 92-116

Parkhurst, D.L., Christenson, S.C., and Schlottmann, J.L., 1989, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma – Analysis of available water-quality data through 1987: U.S. Geological Survey Open-File Report 88-728

Parrish, J.T., 1993, Climate of the supercontinent Pangea: Journal of Geology, v. 101, p. 215-233

______, 1995, Geologic evidence of Permian climate, *in* Scholle, P.A., Peryt, T.M., and Ulmer-Scholle, D.S., eds., The Permian of Northern Pangea: Berlin, Springer-Verlag, p. 53-61.

Parrish J.T., and Petterson, F., 1988, Wind directions predicted from global circulation models and wind directions determined from eolian sandstones of the western United States - A Comparison: Sedimentary Geology, v. 56, p. 261-282.

Parrish, J.T., Ziegler, A.M., and Scotese, C.R., 1982, Rainfall patterns and the distribution of coals and evaporates in the Mesozoic and Cenozoic: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 40, p. 67-101.

Patzkowsky, M.E., Smith, L.H., Marwick, P.J., Engberts, C.J., and Gyllenhaal, E.D., 1991, Application of the Fujita-Ziegler paleoclimate model: Early Permian and Late Cretaceous examples: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 86, p. 67-85.

Prothero, D.R. and Schwab, R. eds, 2004, Sedimentary geology: an introduction to sedimentary rocks and stratigraphy: W.H Freeman and Company, New York.

Pollack, J.M., 1959, Significance of compositional and textural properties of south Canadian River channel deposits, New Mexico, Texas, and Oklahoma. Doctoral Thesis. University of Oklahoma.

__________, 1961, Significance of compositional and textural properties of South Canadian River channel sands, New Mexico, Texas, and Oklahoma, Journal of Sedimentary Petrology, v. 31

Potter, P.E. and Pettijohn, E.F. eds, 1963, Palaeocurrents and basin analysis: Springer, Berlin-Göttingen-Heidelberg.

Reineck, H.E. and Singh, I.B. eds., 1975, Depositional sedimentary environments, corrected reprint of the first edition: Springer-Verlag, New York, Heidelberg, and Berlin.

Schlottmann, J.L., Mosier, E.L., and Breit, G.N., 1998, Arsenic, Chromium, Selenium, and Uranium in the Central Oklahoma Aquifer *in* Christenson, Scott, and Havens, J.S, eds., Ground-water-quality assessment of the central Oklahoma aquifer: summary of investigations: U.S. Geological Survey Water-Supply Paper 2357-A, p. 119-179.

Schlottmann, J.L., and Funkhouser, R.A., 1991, Chemical analyses of water samples and geophysical logs from cored test holes drilled in the Central Oklahoma aquifer, Oklahoma: U.S. Geological Survey Open-File Report 91-464.

Shelton, J.W., 1979, Geology and mineral resources of Noble County, Oklahoma: Oklahoma Geological Survey Bulletin 128.

Shelton, J.W., 1973, Models of sand and sandstone deposits: a methodology for determining sand genesis and trend: Oklahoma Geological Survey Bulletin 118.

Simon, C.L., Hicks, T., Benson, J., and Reilly, M., 2002, Dryland Rivers Research. University of Aberdeen: Retrieved October 15, 2004 from http://www.abdn.ac.uk/~gmi196/DrylandRivers/conference/aberdeen02/lang1.htm.

Smith, S.J., 2002, Downstream fining in a sand-bed segment of the Canadian River. New Mexico, Texas, and Oklahoma: Masters Thesis, Oklahoma State University.

Soreghan, M.J., Soreghan, G.S., and Hamilton, M.A. 2002, Paleowinds inferred from detrital-zircon geochronology of upper Paleozoic loessite, western equatorial Pangea: Geology, vol. 30, no. 8, p. 695-698.

Sternberg H., 1875, Untersuchungen uber Langen-und Querprofil geschiebefuhrencer flusse: Zeitschrift fur Bauwesen, v. 25, p. 483 – 506.

Summerfield, M.A., 1997: Global geomorphology: an introduction to the study of landforms: Addison Wesley Longman Limited, Essex, England.

Tanner, W.F., 1959, Permo-Pennsylvanian paleogeography of part of Oklahoma: Journal of Sedimentary Petrology, vol. 29, no. 3, p. 326-335.

Torrent, J., and Schwertmann, U., 1987, Influence of hematite on the color of red beds: Journal of Sedimentary Petrology, v. 57, p. 682 – 686

U.S. Environmental Protection Agency, 1985, Proposed rule, National primary drinking water regulations; synthetic organic chemicals, inorganic chemicals and microorganisms (part 141): U.S. Federal Register, part IV, November 13, 1985, v 50, no. 219, p. 46,973-46,975.

Waclawik, V., 2003, Neo-tectonism and Lake Eyre *in* Roach, I.C., ed., 2003: Advances in regolith, p. 426-430.

Walker, T.R., Larson, E.E., and Hoblitt, R.P., 1981, Nature and origin of hematite in the Moenkopi Formation (Triassic) Colorado Plateau – A contribution to the origin of magnetism in red beds: Journal of Geophysical Research, v. 86, p. 317-333.

Wood, P.R., and Burton, L.C., 1968, Ground-water resources in Cleveland and Oklahoma Counties, Oklahoma: Oklahoma geological Survey Circular 71

Zeigler, A.M., 1990, Phytogeographic patterns and continental configurations during the Permian period, *in* McKerrow, W.S., and Scotese, E.R., eds., Paleozoic Paleogeography and biogeography: Geological Society of London, memoir 12, p. 363-379.

APPENDICES

APPENDIX A

Discussion of Fluvial Depositional Environments

Introduction

Through lithofacies analysis, lithofacies association and interpretation, grain analysis, and paleocurrent analysis and interpretation, possible paleodepositional systems and environments can be proposed and considered. The following is a brief discussion of possible depositional environments which have characteristics similar to the characteristics present in the Garber Sandstone as determined through observation and data analysis.

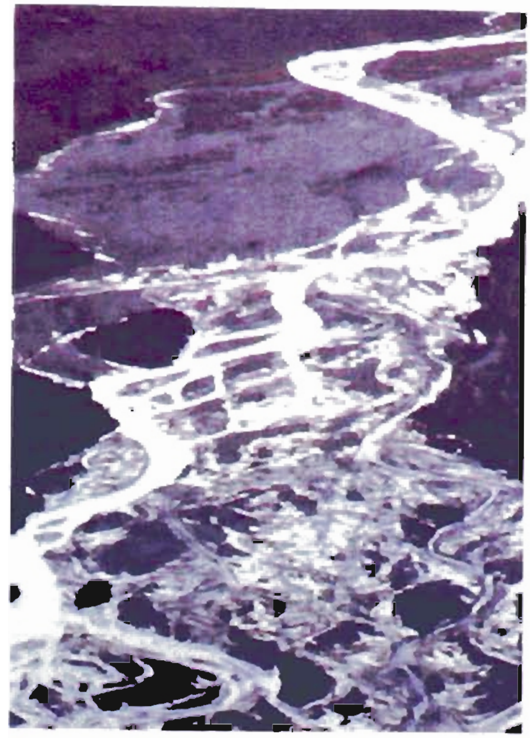
To reiterate, depositional environments are not geomorphically defined locations but rather a set of inter-related processes. Boggs (2001) defines a depositional environment as "a particular geomorphic setting in which a particular set of physical, chemical, and biological processes operate to generate a certain kind of sedimentary deposit" while Fichter and Poché (2001) define it as "a portion of the earth's surface that is characterized by a unique combination of physical, chemical, and biological processes." The Earth's surface topography is the physical manifestation of processes.

Simply put, fluvial is synonymous to river. However, when one thinks of a river one is likely to picture a flowing body of water dissecting the substrate whereas 'fluvial' reflects increased complexity. Fluvial refers to the water's velocity and ability to transport sediment. It also involves the physical geometry of the channel along with its consequential affect on the water's movement and velocity, the sediment size and quantity, and the structures produced as a result of this interplay. Rivers are responsible for erosion, transport, and deposition of sediment. The sediment grains transported by rivers can range in size from boulders to clay size. Furthermore, rivers produce both the processes that erode as well as the processes that deposit sediment and these two seemingly opposite events can be active simultaneously within the same geographic location.

Braided River System

One general classification of river channel morphology is braided. Braided systems occur in the upper reaches of alluvial plains, relatively near the upland source and are associated with rapidly downdropping basins (Prothero and Schwab, 2004). A braided river is characterized by water flowing around exposed areas of sediment called islands or bars; bars being less stable than islands due to less vegetation (Summerfield, 1997). One distinguishing feature of braided river channels is that they are primarily depositional. Many times braided rivers are overloaded with sediment which leads to rapid deposition (Boggs, 2001). Commonly, braided rivers typically have highly variable discharge rates (Summerfield, 1997).

Braided rivers may produce several depositional sedimentary features such as ripples, horizontal bedding, planar cross-bedding, and scour / erosive channel bases but unique to braided rivers are longitudinal bars (sediments deposited in a channel center) and transverse bars (large planar cross-bedded sands). In the reach transitioning from braided to a meandering river, sedimentary features include transverse bars, trough cross-bedding, scour / erosive channel base, and abandoned channel sequences.

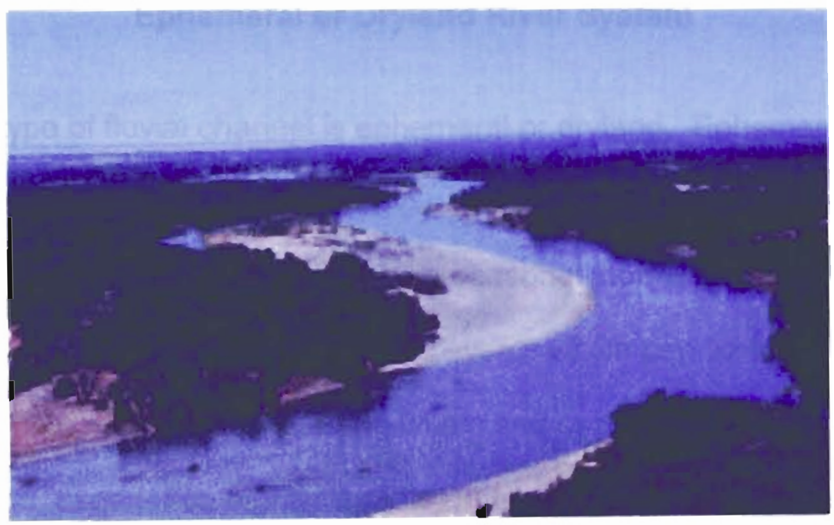


Example of a braided river. Denali National Park, Alaska USA.
(Photo used with permission Copyright: Ross Geredien)

Meandering River System

Another generalized type of channel morphology is meandering. A meandering channel has a sinuous character which results from the water flow incising into the substrate along with eroding in a sideways fashion. Meandering channels form in the lower reaches of a fluvial system where the gradient is much less steep. Meandering channels become increasingly sinuous the farther they are from the source land.

A common feature of meandering channels is the formation of alternating bars along the channel called point bars. Point bars are depositional and form along the inner (convex) bank whereas the outer bank is eroded as a result of the higher flow velocity. A meandering river may produce several depositional sedimentary features similar to what is found in a braided system such as, cross-bedding, planar bedding, and ripples. However, a distinguishing feature of a meandering system is the point bar sequence. As the meanders shift laterally, distinct point bar sequences are created and may be preserved in the rock record. The base of such a sequence may have lag gravels and/or medium sand



Example of a meandering channel. Aerial view of the Sacramento River.

over an erosional base. Next, coarse to medium sand grains are deposited within the channel. Due to the velocity and turbulence of the water, large trough-cross beds and/or high velocity laminations form as sedimentary features. As the point bar matures in form, the sand grains fine upward and small trough cross beds and ripples develop. The sand grains continue to fine upwards as fine to silt sized grains are deposited. Root traces may also be found due to vegetation establishing on the mature point bar. Once the channel migrates away leaving the point bar subaerially exposed, flood plain sediments are deposited. Thus, the sequence is complete. However, due to channel sweep and swing, the channels may migrate and shift back over the point bar, eroding into it and beginning the point bar sequence again. This results in stacked and/or amalgamated bars. A rapid transition from sand to mud deposits is common in meandering systems. These rapid transitions can be seen both laterally and vertically over time.

Ephemeral or Dryland River System

Another type of fluvial channel is ephemeral or dryland. Ephemeral is used to describe channels found in arid environments which experience only intermittent and occasional flow resulting from seasonal storms. Such seasonal storms can produce highly variable discharge events which can be flashy in flow character. Furthermore, channels existing within arid or monsoonal environments can "experience highly variable and unrelated discharge events as a result of extensive and spatially dispersed catchments" (Lang et al., 2003). Such great intrinsic variability within a system results in a wide range of sediments along with locally varying depositional parameters and the resultant sedimentary features.

During Lang's et al. (2003) research involving the dryland rivers of the Lake Eyre basin in Central Australia, several key features and interpretations have been determined. This area of Australia is an arid environment with a monsoonal weather pattern. Detailed studies of the Neales River are still in progress but already illustrate interesting features found within the dryland Neales River environment. The Neales River experiences highly variable discharge rates and during rapidly falling flood stages, lowstand deltas build rapidly. However, these deltas rarely build out into standing water. Sandy mouthbars form the delta front but they amalgamate to form a broad apron.

Waclawik (2003) explains a disconnect between the age of a dryland ephemeral system and its representation in the rock record. "The drainage system rarely flows for any significant length of time. In this context the amount of time that these ephemeral streams have actually carried water represents only a fraction of the time period that these streams have been resident as geomorphological features."

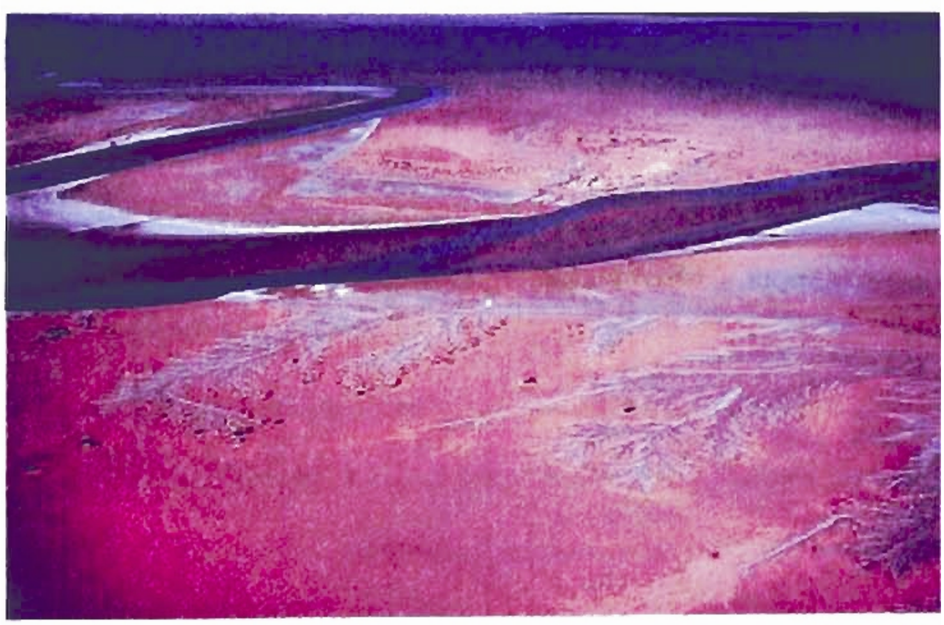
Neales River Fan, Australia, with Lake Eyre at left (Photo used with permission. Copyright: Simon Lang)

Deltaic Systems

As a river enters an ocean, a partially enclosed sea, barrier-sheltered lagoons, or a lake deltas may form. A delta is the result of great quantities of river sediments being supplied to a limited area faster than coastal processes can redistribute them. The Colorado River Delta is a good example. The Colorado River is a meandering river carrying large loads of sediment with headwaters originating in the mountains of Colorado and Wyoming. The Colorado River flows through the Grand Canyon and terminates in the Gulf of California.

In the 1930's, water flowing to the delta was drastically reduced for agricultural development and to a lesser degree for municipal uses. Consequently the delta began to dry up and became increasingly subaerially exposed thus producing a clear image of the delta's morphology.

The Colorado Delta (Photo used with permission. Copyright Airphoto-James Wark)



The Colorado Delta (Photo used with permission. Copyright Airphoto-James Wark)

APPENDIX B

OUTCROP DESCRIPTIONS FROM THE SIX TRANSECTS

Alameda Street; west side of bridge

Approximate lateral distance: 665 feet (202 m)

Approximate vertical distance: 21 feet (6.5 m)

Dominate facies: Planar thin beds and lamina

Secondary facies and sedimentary features: erosive base, massive, planar lamina, very thin beds, thin beds, and ripple lamina

Summary: This outcrop is located on the north side of the road and reflects multiple stacked parallel sand units which are tabular in appearance and dipping to the southwest. Toward the east, this outcrop terminates along the banks of Lake Thunderbird and to the west it thins and terminates into unconsolidated sediments. Toward the western end there exists an isolated channel sand with an erosive base and apparent flow direction dominantly north-south. There is a medium sized bed of mudclast conglomerate below this isolated channel whereas toward the east. At the eastern end of the outcrop, a carbonate clast conglomerate is at the top of the outcrop.

Vertical description: Location is approximately 101 feet from the east terminal end of the outcrop. Overall, it has a black weathering surface with minor red coloration. It reflects multiple stacked and amalgamated sand units all existing parallel to each other. *NOTE: no distinct erosive bases are present unless otherwise noted.*

Base: 26cm unit with 11cm of planar lamina at base gradating into massive for remainder of unit. Weathered surface is black in color and moderately strong. Fresh hand samples are red in color with lesser dark grains; somewhat friable. Grains are very fine, moderately sorted and sub-rounded.

75 cm unit: Mud dominated at base. Basal 30cm planar laminations and planar very thin beds with remaining 45 cm being massive. The fresh surface is red through the basal ½ with a change into white through upper half. Sand grains are very fine, sub-rounded and moderately sorted becoming well sorted as one moves upward. Though the contact between the two colors is sharp, I elected to consider this one unit due to the similarity of grains and lack of definitive evidence for separation.

27 cm unit: lamina and very thin beds throughout unit; neither FUS nor CUS. Weathering surface is black in color with minor green coloration. Fresh surface is whitish with moderate amount of darker grains. Sand grains are very fine, moderately sorted, well rounded and firm slightly friable.

19 cm unit: bedding thickness reflects a FUS from very thin beds gradating into lamina. Intermittent ripple laminations are present throughout. Very top 2 to 3 cm is interbedded sand and mudrock.

Weathering surface is red and green in color with green being most distinct at lamina's bounding surfaces. Sand grains are very fine, sub-rounded and well sorted.

76 cm unit: erosive base. Massive becoming laminated through top 2 cm. This 2cm laminated area thickens to the east becoming 10 cm with an increased presence of mudrock. Sand grains are fine, sub-rounded, and moderately sorted. The weathered surface is black in color while the fresh surface is red and friable. Basal foresets (possibly small bars) are dipping to the west-northwest.

56 cm unit: basal 13 cm unit with ghost planar lamina, a weathered black surface and a fresh surface of red. The sand grains are very fine, well rounded, moderately sorted and friable. 2 cm mudrock existing horizontally for only a short lateral distance disappearing approximately 4½ feet to the west and 8 feet to the east.

41 cm of massive bedding gradating into 16 cm of lamina at top. Fresh color is red. Sand grains are very fine, moderately sorted, sub-rounded, and slightly friable.

15 cm unit: planar lamina. Fresh surface is red in color. Sand grains are fine, sub-rounded, and moderately sorted.

15 cm unit: planar lamina. Fresh surface is red in color. Sand grains are very fine, sub-rounded, and moderately sorted.

24 cm unit: planar lamina. Fresh surface is red in color. Sand grains are very fine, sub-rounded, and moderately sorted.

11 cm unconsolidated sand

68 cm unit: basal 43 cm comprised of lamina and thin beds becoming massive for remaining 25 cm. Toward the center there is a discrete area of ghost planar lamina and possibly ripple lamina. Fresh surface is pink in color gradating into white. Sand grains are very fine, sub-rounded, moderately sorted and friable.

56 cm unit: erosive base. This unit is composed of thin beds throughout basal 12 cm then becomes massive transforming into lamina throughout top 12 cm. Fresh surface is red in color. Sand grains fine, sub-rounded, and well sorted.

60 cm unit: massive but also present is a discontinuous unit approximately 4 cm thick located toward top. This encapsulated discontinuous unit is composed of rippled laminated sands and mudrock.

I considered it part of overall unit since the sands to the east of this discontinuous unit remain intact as one unit.

39 cm covered slope

42 cm unit: massive gradating into lamina and very thin beds throughout top 10 cm. The fresh surface is white/gray in color. The sand grains are fine grained, sub-rounded, well sorted and friable.

10 cm shale / covered slope

28 cm unit: lamina with no FUS or CUS. Fresh surface is white through basal 20 cm gradating into orange toward top. I question if this is actually two units but believe the evidence for its division is weak.

8 cm unit: laminated carbonate clast conglomerate. To the east this unit thickens and becomes two units separated by unconsolidated sand. Within this area, the lower unit is approximately 7 cm lamina topped with 8 cm unconsolidated sediments capped with a 23 cm thick unit of very thin bedded carbonate clast conglomerate.

- To the eastern end of the outcrop there is a displaced rock with surface current ripples.

Alameda Street; 1.9 miles east of bridge; just east of NE 112th Street

Approximate lateral distance: 320 feet (98m)

Approximate vertical distance: 6 feet (1.9m)

Dominate facies: Horizontal planar thin beds and lamina

Secondary facies and sedimentary features: massive, ghost planar laminations, very thin beds, and thin beds

Summary: This outcrop is on the north side of the road and been resurfaced during road construction. This, in combination with weathering and fracture patterns, confuse bounding surfaces. Overall, it is of multiple stacked and possibly amalgamated sand units which are aggrading to the west. The sandstones of this outcrop are also extending into and into the subsurface of the drainage ditch. This outcrop thins eastward and westward into unconsolidated sediment. Approximately 57 feet further to the east is another outcrop of approximately the same size but topographically lower than the outcrop chosen for detailed examination. Due to recent rains, the units are quite wet at the time of evaluation.

Vertical description: Location is approximately 168 feet from the western end of outcrop and appears to be the apex. All sandstones within this outcrop are friable.

Base: Extends into the subsurface with 101 cm above ground. It has a dominantly massive internal structure with discontinuous ghost planar laminations. It is questionable if this should be divided into at least two and possibly three individual units but after examining it for a distance laterally I have determined that the most reasonably consistent bounding surface is as stated. The sand grains gradate from upper-fine to fine and sub-angular at the base into fine and sub-rounded through the middle then upper-fine to fine and sub-rounded toward the top. All samples are moderately sorted.

11 cm ridge of unconsolidated mud and sand has formed atop the bounding surface but does not extend along the z axis.

92 cm unit: the weathering pattern suggesting thin to medium beds with internal laminations. However, when a fresh surface is exposed with a hammer, no internal structures can be seen. The fresh surface is dominantly red in color with minor areas of lighter color and some yellow along with a scattering of dark grains. Sand grains are medium at base fining upwards to fine grained. All sand grains examined are sub-rounded and moderately sorted.

54 cm unit: basal very thin planar beds gradating into thin beds which gradate into massive through top most 20 cm. The fresh surface is red in color. However the top 16 cm has a fresh surface color of yellow. Sand

grains are medium, sub-rounded, and moderately sorted becoming poorly sorted through top 16 cm.

30 cm unit: 10cm thin beds with a thin mud layer separating it from the overlying 20cm bed. The fresh surface is buff in color. Sand grains are fine, sub-rounded, and well sorted.

Alameda Street; 2.3 miles east of bridge near 120th Avenue

Approximate lateral distance: north side of road – 222 feet (68m) and 320 feet (98 m) western and eastern outcrop respectfully. The south side of the road – 297 feet (91m)

Approximate vertical distance: 10 feet (3 m)

Dominate facies: trough cross beds

Secondary facies and sedimentary features: massive, planar thin beds and lamina, erosive bases

Flow direction: Southwest (foresets)

Summary: At this location, there are two outcrops on the north side of the road. The western outcrop is a blocky continuous sand unit which clearly displays multiple discontinuous 30 to 35 cm bands of trough cross beds. It thins into unconsolidated sands to both the east and west. The apparent apex is approximately 133 feet from the western end. It is capped by approximately 2 feet of unconsolidated sands. Below the base is approximately 10 feet of covered slope.

The eastern outcrop is topographically lower and has been partially planed by the highway department. It is composed of multiple sand units which gradually become blocky toward the east. There is no covered slope below the base of this outcrop.

The southern outcrop has been heavily planed and extends approximately 3 feet vertically and 145 feet laterally. In general it is massive at the base with ripple lamina, ripple thin beds, planar thin and medium beds toward the top.

Vertical description: Location is within the eastern outcrop 78 feet from the western end. Overall, it has a black weathering surface. All sandstone units are friable unless otherwise indicated.

Base: 57 cm unit with a massive internal structure gradating into lamina throughout the top 21 cm. The fresh surface color is tan. The sand grains are fine, sub-rounded and moderately sorted.

12 cm unit: erosive base and massive internal structure. Due to the weathering pattern and planed surface it is difficult to clearly distinguish if this is not two beds instead of one. However, since it is questionable I determined it to be one. The sand grains are fine, sub-rounded and moderately sorted.

30 cm unit: laminated internal structure. The fresh surface color is red. The sand grains are very fine, well rounded and well sorted.

120 cm unit: massive. The fresh surface color is white. I question weather this might actually be three units but again can not be definitive. Therefore, I describe it as one based on the consistency of the grains and coloration. The sand grains are very fine to silt, sub-rounded, and moderately sorted. This unit is particularly very friable.

52 cm unit: massive. The fresh surface color is tan to orange. The sand grains are fine to very fine, sub-rounded, and moderately sorted.

24 cm unit: massive. Fresh surface color is gray. Sand grains are fine, sub-rounded, and moderately sorted.

16 cm unit: thin beds gradating into lamina. The fresh surface color is red. The sand grains are fine, sub-angular, and poorly sorted. This unit is firm to slightly friable.

- As previously mentioned, this outcrop becomes blocky toward the eastern end. This blocky area displays erosive bases and undulating thicks and thin with an internal structure reflecting thin to medium cross beds at bases.

Alameda Street; 2.8 miles east of bridge; near water tower and across from the Central Oklahoma Master Conservancy District Reservoir Pumping Plant

Approximate lateral distance: 83 feet (25 m)

Approximate vertical distance: 4.5 feet (1.5 m)

Dominate facies: Ripple lamina

Secondary facies and sedimentary features: massive, planer laminations, cross laminations, and ripple lamina, erosive bases

Flow direction: southeast (foresets)

Summary: This outcrop is located on the north side of the road. Overall it is three to four units with approximately 3 feet of covered slope below the base. The eastern and western ends thin into unconsolidated sediments.

Vertical description: Location is approximately 38 feet from the western end.

Base: 54 cm measured above surface but unit extends into the subsurface. The internal structure consists of southeasterly dipping lamina (forests). The fresh surface color is buff with minor dark grains. The sand grains are medium, sub-rounded and moderately sorted.

30 cm unit: ghost planar laminations are noted within basal 16 cm becoming ripple lamina throughout top 7 cm The sand grains are fine, sub-rounded, and moderately sorted.

19 cm unit: planar laminated internal structure. The fresh surface is purplish in color. The sand grains are very fine, well rounded and well sorted.

32 cm unit: ripple lamina throughout. The fresh surface is purple in color. The sand grains are very fine, well rounded and well sorted.

Alameda Street; 3.2 miles east of bridge

Approximate lateral distance: 179 feet (55m)

Approximate vertical distance: 8.7 feet (2.7m)

Dominate facies: massive

Secondary facies and sedimentary features: erosive bases, massive, planar laminations, cross-laminations, and ripple laminations

Summary: This outcrop is on the north side of the road with half artificially resurfaced and the other half blocky in nature with natural weathering. At both the eastern and western end it becomes discontinuous and thins into unconsolidated sediments. All units are friable.

Vertical description: Located 93 feet from western end.

Base: 35 cm measured above surface but also extends into the subsurface. This unit is massive. The fresh surface is pink to buff in color. The sand grains are fine to medium, sub-angular, and moderately sorted.

50 cm unit: erosive base and laminated internal structure throughout basal 17 cm then transitioning into massive. The fresh surface is buff in color. Sand grains are medium to fine, sub-rounded, and moderately sorted.

47 cm unit: basal lamina transitioning into massive then into planar laminations toward top. There is also a small isolated area of planar cross lamination. Fresh surface is buff in color with scattered dark grains. Sand grains are medium to fine, sub-rounded, and moderately sorted.

115 cm unit: erosive base. It has planar lamina at base with remainder being massive. Fresh surface is buff in color. The sand grains are medium to fine, sub-rounded, and poorly sorted.

17 cm unit: ripple lamina. The fresh surface color is pink/buff in color. The sand grains are medium, sub-rounded, and moderately sorted.

Alameda Street; 3.6 miles east of bridge near Indian Point Visitor Information Center

Approximate lateral distance: 219 feet (67m)

Approximate vertical distance: 11 feet (3.5m)

Dominate facies: Horizontal to low angle planar thin beds and laminations

Secondary facies and sedimentary features: massive, planar laminations, erosive bases

Flow direction: east (foresets)

Summary: This outcrop is composed of several stacked sandstone units; some separated by unconsolidated sediments. All units are aggrading to the west.

Vertical description: Location is 149 feet from west; along side the area G. Gromadzki obtained the gamma ray readings.

Base: 14 cm existing above surface but extends into the subsurface. It has a massive internal structure transitioning into thin and very thin beds toward the top. The fresh surface is buff in color. The sand grains are fine, well rounded, and well sorted.

14 cm unit: very friable laminations; medium grain size

26 cm unit: erosive base. Basal 11 cm is composed of thin beds which have a laminated internal structure. These thin beds grade into massive toward the top. The fresh surface is both buff and red in color. The sand grains are fine, well rounded and well sorted.

180 cm unit: erosive base with eastern dipping foresets 1 cm in thickness. Horizontal planar lamina truncated to the west by a unit of high angle easterly dipping small bars. The sand grains are fine, well rounded and well sorted.

7 cm unit: laminated silty sands

63 cm unit: erosive base. Basal 25 cm is composed of thin planar low angle beds (easterly dipping) gradating into medium beds. The sand grains are upper-fine to lower-medium, sub-rounded and moderately sorted.

25 cm unit: planar low angle thin beds gradating into planar horizontal lamina toward top. The sand grains are fine, sub-rounded and moderately sorted.

10cm unit: massive internal structure. The sand grains are upper-fine, sub-rounded and moderately sorted.

Alameda Street; 3.9 miles east of bridge

Approximate lateral distance: 230 feet (70m)

Approximate vertical distance: 8 feet (2.5m)

Dominate facies: ripple lamina

Secondary facies and sedimentary features: massive, ripple lamina, thin and medium beds.

Summary: This outcrop is located on the north side of the road. Overall it consists of multiple stacked sand units. Toward the west it thins into unconsolidated sediments. Toward the east it becomes discontinuous and thins into unconsolidated sediments. East of the location chosen for the vertical section are medium beds of ripple lamina draped over the underlying unit and truncated by the overlying unit. West of the location chosen for the vertical section there are thin beds draped over underlying unit.

Vertical description: Location is 99 feet from western end. This area also appears to be the apex of this outcrop. The weathered surface is black in color. Unless otherwise noted, this outcrop is weak but non-friable.

Base: 130 cm unit with massive internal structure and a FUS of grain size. At base the sand grains are fine to medium, sub-rounded and poorly sorted transitioning into fine, sub-rounded and moderately sorted grains toward top. The fresh surface is red in color throughout lower 2/3 but becomes buff in color through upper 1/3.

23 cm unit: ripple lamina. Fresh surface is pink in color. Sand grains are medium, sub-rounded, and moderately sorted.

14 cm: ripple lamina. Fresh surface is white in color. Sand grains are medium, sub-rounded, and moderately sorted. This unit is moderately strong.

30 cm unit: massive internal structure. The fresh surface is pink and white in color. The grains are fine to medium, sub-rounded, and moderately sorted.

17 cm unit: ripple lamina with lamina thickness reflecting a CUS.

40 cm unit: thin to medium beds with an internal structure of ripple lamina. The fresh surface is dominantly pink in color but some orange is also present. The sand grains are medium, sub-rounded, and moderately sorted.

Alameda Street; 4.0 miles east of the bridge and next to the marina

Approximate lateral distance: 204 feet (62m) plus several feet extending past the water's edge

Approximate vertical distance: 8.5 feet (2.6m)

Dominate facies: horizontal to low angle planar thin beds and lamina

Secondary facies and sedimentary features: carbonate clast conglomerate, massive, ripple lamina, thin and medium beds, carbonate clast conglomerate

Flow direction:

Summary: This outcrop is on the north side of the road (parking area). It thins into unconsolidated sands to the west but extends to the water's edge toward the east.

Vertical description: Location is approximately 50 feet from the western end of this outcrop. The weathered surface is dominantly black while the fresh surface is red, orange, and pink in color. Units are slightly friable.

Base: extends into the subsurface with 27 cm above ground. This unit is dipping to the west. It has a dominantly massive internal structure with minor cross bedded laminations. Very fine grain size, sub-rounded, and moderately sorted.

124 cm unit; erosive base with lower 75 cm massive in structure and upper 42 cm has thin beds with an internal structure of planar laminations.

There is also an area of low angle small bars dipping to the east. Sand grains are very fine, well rounded, and well sorted.

60 cm unit: erosive base and internal structure of low angle planar lamina (dipping to the west). Fine grained, sub-rounded. and moderately sorted.

19 cm mud with minor amounts of fine grained sand

26 cm of three beds approximately 7 to 8 cm thick carbonate clast conglomerate.

1.2 meters covered slope.

Rock Creek; 1.1 miles east of Pebbly Road – Western and Eastern outcrop

Approximate lateral distance: Western - 156 and 220 feet (47.5m and 67m); north and south respectfully. Eastern - 270 and 358 feet (82m and109m); north and south respectfully

Approximate vertical distance: 5.5ft (170m)

Dominate facies: planar thin beds / lamina

Secondary facies and sedimentary features: massive, ripple lamina, planar thin and medium beds, erosive base, trough cross beds, planar cross lamina

Flow direction:

Overall summary: Within this area there are two independent outcrops I will refer to as the 'western' and 'eastern'. Furthermore, each outcrop exists on the north and the south side of the road. For the purpose of this study I have chosen to evaluate each outcrop's northern and southern exposure as independent outcrops though they are actually a continuation of each other.

Western outcrop

North side of road

Summary: Stacked sandstone units in which the western end thins and becomes discontinuous terminating into unconsolidated sediments. Toward the east, at approximately 81 feet from western end, it thins and becomes discontinuous with an increasing ratio of shale for approximately 75 feet but outcrop's integrity remains intact.

Vertical description: Location is 18 feet from western end.

Base: 17 cm unit of thin beds. Sand grains are very fine, sub-rounded, and moderately sorted.

58 cm unit: erosive base. It is massive at the base becoming laminated throughout the upper 26 cm. The sand grains are fine, sub-rounded and moderately sorted.

1 cm: shale

23 cm unit: planar laminated internal structure. Sand grains are fine, sub-rounded and moderately sorted.

Approximately 1 meter covered slope

Vertical description: Location is 28 feet from western end.

Base: 25 cm unit with erosive base and massive internal structure. The weathered along with the fresh surface is purple in color. Unit is moderately strong. Sand grains are upper fine, sub-rounded and well sorted.

17 cm: shale

28 cm unit: erosive base, thin beds with a massive internal structure at the base gradating into planar horizontal lamina. Unit is moderately strong. Sand grains are very fine to silt, well rounded, and moderately sorted.

10 cm unit: planar lamina. Sand grains are medium, sub-rounded, and moderately sorted.

56 cm unit: basal 14 cm of planar cross laminations transitioning into approximately 46 cm of thin beds with a laminated internal structure. Foresets are dipping to the west. Sand grains are upper fine coarsening upward into fine - upper medium toward top. Sand grains are sub-rounded and moderately sorted throughout this unit. Eroded top surface

19 cm unit: sandy-silty lamina conformably overlying the lower unit then transitioning into sandy soils.

South side of road

Summary: Approximately three stacked units with erosive bases, cross-bedded lamina, and trough cross-bedding. Weathered surface is black in color. Throughout this outcrop the weathered surface is black and red in color while fresh surface color is red. Sandstone units thin into unconsolidated sediments at both the eastern and western end.

Vertical description: Location is 102 feet from the western end.

Base: 51 cm dominantly massive with discontinuous ghost planar lamina. Fresh surface is orange to buff in color. This unit is firm to slightly friable.

7 cm shale unit: discontinuous laminated shale unit changing laterally into low angle planar lamina

32 cm unit: erosive base with a massive structure throughout basal 19 cm gradating into planar laminations toward top.

< 20 mm shale

81 cm unit: erosive base with a massive internal structure

18 cm unit: thin beds with internal planar lamina. The fresh surface is orange in color. Sand grains are upper fine, sub-rounded, and moderately sorted.

Vertical description: Location is approximately 125 feet from western edge.

Overall, lamina and thin beds dominate this outcrop. Truncation and erosive bases are also prevalent.

Base: 76 cm unit with dominantly massive unit with discontinuous ghost lamina.

92 cm unit: thin planar beds

20 cm unit: horizontal planar laminations throughout basal 8 cm which are truncated by low angle planar laminations present throughout the remainder of unit.

Eastern outcrop

Summary: These units form dominantly continuous sand bodies extending and aggrading to the west. These outcrops are comprised of approximately four stacked and amalgamated sandstone units.

North side of the road

Summary: As previously mentioned, this outcrop is comprised of approximately four stacked and amalgamated sandstone units. It is also dissected by a lane. Easterly dipping foresets truncated by horizontal lamination can be seen toward the eastern end of the outcrop while toward the western end there are foresets dipping to the west. However, the dominate foreset dip direction for the outcrop is to the west.

South side of the road

Summary: Overall, this outcrop is dominantly massive at the base with ghost planar laminations seen as one moves upward through the outcrop. The western end thins into unconsolidated sediments. There are several very large trash items in this area making it difficult to examine the outcrop. Within the measured outcrop, there are two units of laminated shale rich sand. Both are dipping to the west. Measuring from the west, the lower unit extends laterally from 86 to 127 feet while the overlying unit extends from 72 to 92 feet. The lower unit thins to the west while the overlying unit thins to the east. An erosive base can be seen toward the eastern end but then extends into and below the subsurface of the drainage ditch. This outcrop is dissected near its eastern end by a road.

The following lateral measurements are taken from the western end of the outcrop. At 11 feet the bedding thickness reflects a FUS with basal medium beds transitioning into thin beds which then grade into lamina. This FUS is then capped by a medium bed with massive internal structure. At 33 feet there are distinct planar laminations. At 50 feet ghost trough lamina are present. Cross laminations are present at 118 feet in the upper portion of the outcrop.

Vertical description: Location is approximately 167 feet from the west.

Base: 26 cm unit with a laminated internal structure. The fresh surface is red and white in color. The sand grains are fine to very fine, well rounded, and moderately sorted.

27 cm unit: laminated internal structure. The fresh surface is red and white in color. The sand grains are very fine, rounded, and moderately sorted.

41 cm unit: laminated internal structure. Fresh surface is red at the base transitioning into white toward the middle then displaying a broken red and white pattern toward the top. The sand grains are fine, rounded and well sorted.

72 cm unit: massive internal structure. The fresh surface is red in color. The sand grains are medium, sub-rounded and moderately sorted.

24 cm unit: a medium bed with a ripple laminated internal structure. The fresh surface is red in color. The sand grains are medium, sub-rounded, and moderately sorted.

Rock Creek Road; 1.5 miles east of Pebbly Road

Approximate lateral distance: 500 feet (152m); south side of the road

Approximate vertical distance: 9.5 feet (2.9m)

Dominate facies: planar lamina

Secondary facies and sedimentary features: horizontal planar lamina and cross lamination, massive bedding, trough cross beds, ripple lamina, erosive base,

Flow direction: west

Summary: This outcrop exists on both the north and the south side of the road. It has been planed by the highway department and between the planed surface and the weathering pattern the sedimentary features are difficult to differentiate. Overall, this outcrop is approximately three stacked units with erosive bases. Within each outcrop, the basal unit extends into the subsurface in the drainage ditch.

North side of the road

Summary: The basal unit is dominated by thin beds but toward the west, it is massive transitioning vertically into westerly dipping thin beds. The middle unit reflects a FUS as medium beds grade into thin beds then into lamina. The top most unit has an erosive base with basal thin beds down-cutting into the lower unit of planar thin beds and lamina. Toward the far western end, the basal unit has an erosive base with cross laminations. The two overlying units are blocky and weathered such that sedimentary structures are increasingly difficult to distinguish but discontinuous ghost trough laminations are present. Toward the west, this outcrop thins into unconsolidated sediments with unconsolidated laminated shale and laminated siltstones below the erosive base. A drive dissects the outcrop. The eastern terminal end of the outcrop thins into unconsolidated sediments but the base extends into the surface.

South side of the road

Summary: Though this outcrop extends for a total of approximately 500 feet it is discontinuous resulting in two independent outcrops which I will refer to as western and eastern. Erosive bases are present within both outcrops.

The western outcrop consists of stacked units interspersed with blocky discontinuous sandstones. The blocky areas appear to be the result of fracturing and weathering. Planar thin beds, laminations and cross-beds can all be seen in discontinuous discrete areas. Where present, forests are dipping to the west. As one moves laterally toward the east, there are thin beds dipping to the east in the upper units while they dip to the west in the lower units. Ghost lamina with truncation can be seen at this contact. The terminal eastern end becomes blocky and thins slightly before ending into unconsolidated sediments. The western end also thins into unconsolidated sediments but lacks the blocky appearance.

The eastern outcrop is of stacked sandstone units of planar laminations and thin beds; most of which are dipping to the west. The basal unit is truncated by the overlying unit. The following measurements are from the west end of this outcrop. At 39 feet there are ghost laminations through the majority of the outcrop; all dipping to the west. At 66 feet there are ghost horizontal planar laminations throughout this area. Planar laminations within a channel that cuts perpendicular to the overall outcrop can be seen at 105 feet. At 157 feet there are planar horizontal laminations throughout. Toward the east it is truncated by a drive but further on, past the drive, it thins into unconsolidated sediments. The weathered surface is dominantly black in color. The units are somewhat weak but non-friable.

Vertical description: location is 87 feet from the east.

Base: 73 cm unit of horizontal lamina. Sand grains are fine to medium, sub-rounded, and moderately sorted. The fresh surface is pink in color.

25 cm unit: horizontal planar lamina. Sand grains are fine to medium, sub-rounded, and moderately sorted. The fresh surface is pink in color.

50 cm unit: ghost laminations dipping to the west. These are truncated by lamina dipping to the east. The fresh surface color is buff. The sand grains are medium to fine grained, sub-rounded, and moderately sorted.

99 cm unit: massive transitioning into ghost thin beds transitioning into laminations throughout top 25 cm. Within this top 25 cm there is also a

small area of planar cross laminations. Fresh surface color is pink. Sand grains are fine to medium, sub-rounded, and moderately sorted.

36 cm unit: Very thin beds at base CUS into thin bed at middle which FUS into lamina. Sand grains are upper fine to very fine, rounded, and moderately sorted.

10 cm unit: ripple laminations transitioning into unconsolidated sandy shale laminations. Sand grains are very fine, rounded, and well sorted.

46 cm covered slope

Rock Creek Road; 1.8 miles east of Pebbly Road

Approximate lateral distance: 210 and 110 feet (64m and 34m); north and south side of the road respectfully

Approximate vertical distance: 11.7 feet (3.6m)

Dominate facies: ripple lamina

Secondary facies and other sedimentary features: ripple lamina, massive, erosive bases

Summary: This outcrop extends to both the north and the south side of the road. The weathered surface is dominantly pink and black in color. The lower units extend into the subsurface.

The southern outcrop becomes discontinuous and thins into unconsolidated sediments toward its western terminus. Toward the eastern terminal end, it thins into unconsolidated sediments. The western outcrop thins into unconsolidated sediments at the western terminal end but extends into the subsurface at its eastern terminus.

Vertical descriptions: Southern outcrop is located approximately 93 feet from western edge.

Base: massive, extending into the subsurface and flooring the ditch.

38 cm: erosive base with massive internal structure.

23 cm unit: laminated very fine grained sandstone throughout lower 10 cm transitioning into massive fine grained sandstone

21 cm unit: ripple lamina

Northern outcrop is located approximately 98 feet from the western end

Base: 43 cm unit of ripple lamina. The weathered surface is black in color while the fresh surface is purple in color. Sand grains are upper fine, sub-rounded, and moderately sorted.

19 cm of unconsolidated sandy sediments

20 cm unit: ripple lamina. The fresh surface is pink in color. Sand grains are lower fine to upper medium, sub-rounded, and moderately sorted.

19 cm of unconsolidated sandy sediments

20 cm unit: ripple laminated. Fresh surface color is pink. Sand grains are lower fine, sub-rounded, and moderately sorted.

42 cm of unconsolidated sandy sediments

30 cm unit: ripple lamina. Sand grains are upper fine, sub-rounded, and moderately sorted.

14 cm of unconsolidated sandy sediments

46 cm unit: massive internal structure. Fresh surface is buff to white in color. Sand grains are fine, sub-rounded, and moderately sorted.

105 cm unit: this is a group of 8 amalgamated sandstone units each with a ripple laminated internal structure. Each exhibits erosive bases with truncation of the lower unit's laminated structures. Sand grains are lower fine, sub-rounded, and moderately sorted throughout. The following are the measured thicknesses of each unit along with its fresh surface color. 25 cm – pink; 9 cm – light purple, 7 cm – light purple; 11 cm – pink; 17 cm – white; 11 cm – red; 23 cm – red; 11cm – red.

Rock Creek Road; 2.2 miles east of Pebbly Road

Approximate lateral distance: 75 feet (23m) west of drive way. 222 feet (67.7m east of drive way

Approximate vertical distance: 6 feet (180m)

Dominate facies: Massive

Secondary facies and sedimentary features present: erosive bases

Summary: This outcrop is on the north side of the road and is dissected by a driveway. It is dominated by thick variegated mudrock with only three discontinuous sand units. The sand units on the west side of the drive thin and become discontinuous into unconsolidated sediments. A generalized representation of the outcrop on the western side of the drive is as follows: 60 cm basal unit of massive internal structure, 20 cm unit of ripple lamina, 34 cm unit of very thin beds of ripple lamina. The following vertical descriptions are taken on the east side of the drive.

Vertical description: location is at the eastern edge of the drive. These sand units dip to the east.

Base: 81 cm unit of massive internal structure

15 cm of mudrock

32 cm unit: thin beds with massive internal structure with bed thickness reflecting a FUS. This unit is truncated by the overlying unit

40 cm unit: erosive base. Massive

46 cm of sand rich mudrock

Vertical description: location is 100 feet to the east of the drive

Base: 31 cm of mudrock

57 cm unit: massive. Fresh surface color is white to pale pink. Unit is moderately strong. Sand grains are very fine, sub-rounded, and moderately sorted.

91 cm of sand rich mudrock

Vertical description: location is 119 feet to the east of the drive

Base: 24 cm sand rich mudrock

31 cm unit: thin beds of siltstones with discontinuous lamina. Fresh surface color is white. Unit is moderately strong. Sand grains are upper very fine to silt, well rounded, and moderately sorted.

45 cm of sand rich mudrock

53 cm unit: this is an easterly continuation of the 57 cm unit described in the previous vertical section. It is massive with the fresh surface white to pale pink in color. Unit is moderately strong. Sand grains are very fine, sub-rounded, and moderately sorted.

Rock Creek Road; 2.5 miles east of Pebbly Road near house construction

Approximate vertical distance: 6.5 feet (2m)

Dominate facies: horizontal and low angle planar thin beds and laminations

Secondary facies and sedimentary features: planar cross beds, erosive bases, massive, low angle planar horizontal thin beds, ripple lamina, shale/laminated siltstone

Flow direction: Northwest

Summary: This area has three outcrops; two on the south side of the road and one on the north side of the road. The outcrops on the south side of the road will be referred to as western and eastern. The western outcrop is of blocky sandstone located at the top of the slope, producing a topographic high. It thins into unconsolidated sediments at both its eastern and the western terminus. Its weathered surface is buff pink to red in color. The eastern outcrop consists of three stacked sandstone units. The top unit is separated from the lower units by sand rich mudstone. The basal unit extends into the subsurface. The outcrop on the north side of the road is a continuation of the eastern outcrop on the south side of the road; three stacked sandstone units.

Vertical description: the western outcrop on the south side of the road approximately 70 feet from its western terminus.

Base: 48 cm unit with an erosive base and planar horizontal very thin to thin beds throughout. The fresh surface is red in color. The sand grains are fine, rounded and moderately sorted.

68 cm unit: erosive base with ghost planar cross-beds. The fresh surface is red in color. The sand grains are lower fine to upper medium, sub-rounded, and poorly sorted.

The following two units do not have distinct erosive bases but are separated by differential weathering.

64 cm unit: foresets dipping to the northwest through the basal 32 cm then transitioning into massive. The fresh surface is buff in color. The sand grains are medium, sub-rounded and poorly sorted.

30 cm unit: ghost planar horizontal thin beds. Fresh surface is red in color. Sand grains are upper medium, sub-rounded and poorly sorted.

Vertical description: the eastern outcrop on the south side of the road approximately 46 feet from its west terminus

Base: 36 cm measured above the surface but also extends into the subsurface. It has a massive internal structure. Sand grains are lower fine, sub-rounded, and moderately sorted.

35 cm unit: erosive base down-cutting into 7 cm of shale and laminated siltstone. This unit is comprised of very thin to thin planar horizontal beds. The sand grains are fine, rounded and moderately sorted.

95 cm unit: planar horizontal thin beds throughout basal ½ that transitioning into massive. Weathering patterns render this interpretation slightly suspect.

Vertical description: this outcrop is on the north side of the road. The location is approximately 52 feet from the western terminus.

Base: 75 cm measured above the surface but extends into the subsurface. The sand grains are lower fine, rounded, and moderately sorted.

44 cm unit: erosive base with low angle planar horizontal thin beds dipping to the west at the base becoming increasingly horizontal then into massive toward the top. The sand grains are fine, rounded and moderately sorted.

97 cm unit: thin beds of ripple lamina in lower 33 cm gradating into planar horizontal low angle very thin beds dipping to the east for 23 cm then gradating into medium beds which gradate into massive. Ripple lamina dominates in the upper most portion of this unit. This unit does not have

an erosive base but is separated from the lower unit by differential weathering.

Rock Creek Road; 2.6 miles east of Pebbly Road

Approximate vertical distance: 11.5 feet (3.5m)

Dominate facies: Ripple beds and laminations

Secondary facies and sedimentary features: massive. erosive bases, truncation,

Flow direction: west

Summary: This area is composed of five individual outcrops; two on the north side of the road and three on the south side of the road. On the north side of the road producing the location's topographic high is a channel sand that is situated several meters above the lower but dominate outcrop. I have divided the lower dominate outcrop laterally into three sections based on appearance and physical characterization. The western section (0 – 182 feet measuring from the west) is possibly of stacked and amalgamated sandstone units but it may also be one continuous sand body. The weathering pattern along with the planed surface makes differentiation difficult. The western terminus thins into unconsolidated sediments while the eastern end thins and becomes topographically lower resulting in its top unit becoming the middle section's basal layer. There are ghost planar horizontal laminations throughout.

The middle section (182 – 297 feet measuring from the west) is dominated by thin to medium beds of ripple lamina. The sand grains are medium, rounded, and moderately sorted. As these beds extend vertically, they become slightly wavy in appearance. I have interpreted these units to represent a crevasse splay. There is some minor post-depositional fracturing. These rippled sandstone beds are interbedded with friable laminated upper fine to silt size sands. Many of the sandstone beds have erosive bases along with several areas of truncation.

Vertical description: Location is on the north side of the road at approximately the center of the crevasse-splay

Base: 30 cm thin to bed beds upper fine grained sandstone, red in color. Grains are rounded and moderately sorted

30 cm trough cross-beds; sand grains are upper fine, rounded and moderately sorted, weathered and fresh surface is red

36 cm shale and laminated siltstones

30 cm thin beds with erosive bases, discontinuous high angle and trough cross beds can be seen laterally

30 cm shale and laminated siltstones

20 cm thin to medium sandstone beds of ripple lamina. Grains are fine to very fine, rounded and moderately sorted. Weathered and fresh surface is red in color.

186 cm mudrock

The eastern most section (from 297 – 530 feet measured from the west) is composed of two arched and stacked sandstone units with the topmost unit absent from the apex of the arch eastward.

Vertical description: location is on the north side of the road at approximately 312 feet from the west.

Base: 82 cm unit: massive with the fresh surface being red in color. The sand grains are medium, rounded, and moderately sorted.

48 cm unit: thin beds with fresh surface pink to red in color at the base transitioning into white toward the top. The sand grains are very fine, rounded and moderately sorted.

93 cm of sand rich mudrock

1.7 meter unit: planar horizontal thin to medium beds with a massive internal structure. The sand grains are medium, rounded and moderately sorted.

South side of the road

Summary: Toward the east, the base is dominantly massive units with erosive bases. These units thin vertically into very thin beds of ripple lamina inter-bedded with sand rich mudrock. Overall, these units are dipping to the west – southwest and are possibly aggrading to the west. Toward the western end of the outcrop, producing the location's topographic high, is the continuation of the channel sand previously mentioned which is located on the north side of the road.

Franklin Street and Pebbly Road intersection

Approximate lateral distance: 338 feet (103m)

Approximate vertical distance: 4 feet (1.3m)

Dominate facies: horizontal planar thin beds and lamina

Secondary facies and sedimentary features: ripple lamina, massive, erosive bases

Flow direction: northwest; parting lineations of 300°

Summary: This outcrop is on the north side of the road. To the west, it thins and becomes discontinuous, completely terminating at the intersection with Pebbly Road. The lateral distance stated above reflects the sandstones that are continuous in nature. It does not include the discontinuous sand units. This outcrop is of both amalgamated sand units and discrete stacked sand units which are separated both vertically and laterally by unconsolidated sediments. This outcrop is dominated by planar thin beds and lamina. Also present but to a much lesser degree are ripple lamina. The sand grains are predominately fine to very fine, well rounded (occasionally sub-rounded), and mostly well sorted. The eastern end of this outcrop becomes blocky and thins into unconsolidated sediments. At approximately 148 feet as measured from the west, planar laminations are draped over a topographic high; possibly over-bank deposits.

Vertical description: location is approximately 31 feet from western end of the continuous sand units.

Base: 44 cm unit that is massive with discontinuous ghost planar laminations. It extends into the subsurface and floors the drainage ditch. The weathered surface is black in color while the fresh surface is red in color. The sand grains are fine, well rounded to slightly sub-rounded, and moderately sorted.

24 cm unit: erosive base and planar laminations. The weathered surface is black in color while the fresh surface is red in color. The grains are very fine, well rounded, and well sorted.

66 cm unit: appears to have been deposited atop the underlying unit in a conformable manner without evidence of erosion. The weathered surface is black in color with minor purple coloration. This unit's strength is somewhat friable. The fresh surface is light red at the base gradating into a buff-pink color toward the top. The internal sedimentary structure reflects a FUS as massive at the base transitioning into thin beds then into laminations. The sand grains are very fine, well rounded, and well sorted.

Franklin Street; 0.1 mile from Pebbly Road intersection

Approximate lateral distance: 285 feet (87m)

Approximate vertical distance: 6.5 feet (2.7m)

Dominate facies: massive

Secondary facies and sedimentary features: planar horizontal thin beds and laminations

Summary: Overall, this outcrop is composed of stacked sand units alternating with unconsolidated sediments both vertically and horizontally. A portion of this outcrop has been planed. Thin beds and laminations are not as apparent and this outcrop appears to be predominately massive. Toward the east, it becomes blocky with internal laminations and thin beds at approximately 177 feet. Where blocky, it appears to be one unit.

Vertical description: location is approximately 72 feet from the western end of continuous units.

Base: 77 cm unit, massive and extends into the subsurface. The weathered surface is black and red in color and is moderately strong. The fresh surface is red to pink at the base transitioning into buff color at the top. The sand grains are fine, sub-rounded, and moderately to well sorted.

40 cm: massive with a black and pink weathered surface. The fresh surface is pink in color. Sand grains are fine, sub-rounded to rounded, and moderately to well sorted.

24 cm unit: massive with a weathered surface that is pink and orange while the fresh surface is pink with intermittent white color. The sand grains are fine to very fine, well rounded, and moderately sorted.

19 cm unit: massive, fine grained, sub-rounded, and moderately sorted

16 cm unit: massive. The fresh surface is buff to orange in color. The sand grains are very fine, well rounded, and moderately sorted.

20 cm unit: massive with the fresh surface being buff in color. The sand grains are very fine, well rounded, and moderately sorted.

15 cm unit: massive. The fresh surface is buff to orange in color. The sand grains are fine, well rounded, and moderately sorted.

17 cm unit: massive. The fresh surface is pink in color. The sand grains are fine to medium, sub-rounded, and moderately sorted.

46 cm of very friable shale and laminated siltstones transitioning into unconsolidated sediments.

Franklin Street; 0.5 miles from Pebbly intersection

Approximate lateral distance: 297 feet (90m)

Approximate vertical distance: 5 feet (1.5m)

Dominate facies: massive

Secondary facies and sedimentary features: horizontal planar thin beds and lamina, truncation

Summary: This outcrop is on the north side of the road and is a combination of stacked sand units along with discrete sand units separated by unconsolidated sediments. These sand units are aggrading to the west. Overall, the sand units are dominated by massive bedding features with lesser amounts of planar laminations and thin beds. There are several areas of truncation. At approximately 80 feet from the west, the lamina are dipping toward the east whereas at 34 feet they are dipping toward the west.

At approximately 48 feet from the west end is a unit of approximately five blocky stacked sand units. At the base is 48 cm of thin beds with internal structure of lamina. This 48 cm unit is truncated by a 78 cm of massive sands transitioning into thin beds then into laminations.

At approximately 75 feet from the west end is a unit of approximately 50 cm of laminations truncated by a 30 cm blocky massive sand unit.

Vertical description: taken at approximately 105 feet from the western end. G. Gromadzki's gamma ray readings were taken at approximately 125 feet.

This area is three stacked sand units of which the base extends into the subsurface and floors the drainage ditch

Base: 88 cm unit, massive. Weathered surface is black in color with minor amounts of pink and orange. It is moderately strong. The fresh surface is buff in color. Sand grains are fine, sub-rounded, and moderately sorted.

35 cm unit: ripple lamina. The weathered surface is pink and orange in color and moderately strong. The fresh surface is red in color.

28 cm unit: massive. The sand grains are very fine to fine, sub-rounded, and moderately sorted. The weathered surface is pink and orange in color and moderately strong. The fresh surface is red in color.

Franklin Street; 2.6 miles east of Pebbly intersection

Approximate lateral distance: 181 feet

Approximate vertical distance:

Dominate facies: massive

Secondary facies and sedimentary features: ripple lamina, planar cross beds, truncation

Summary: This outcrop is dominantly on the north side of the road but extends to the south side. This outcrop has an area that has been planed by the highway department and an area of blocky sandstone units. The planed portion extends laterally for 106 feet with the remaining outcrop being blocky. The blocky units have an internal structure of thin to medium beds with discontinuous ripple laminations present in the upper most portion of the outcrop. It is difficult to confidently identify individual units and internal organization. I determined that this planed portion is composed of several amalgamated beds. The basal unit extends into the subsurface and floors the drainage ditch. Ripple lamina are possibly present at the base of each unit but the weathering pattern makes it difficult to determine. Since the evidence is tenuous at best, I will call it a massive internal structure.

At approximately 147 feet from the western terminus, there are isolated areas of planar cross-laminations along with interbedded thin to medium beds and thin mudrock units. At approximately 151 feet there is an area of high angled planar lamination with truncation.

Vertical description: location is 60 feet from western end.

Base: 22 cm measured above the surface but also extends below the surface. It is massive with its weathered surface being black in color while the fresh surface is red. The sand grains are fine, sub-angular, and poorly sorted.

120 cm unit: massive with sand grains being medium to fine, sub-rounded, and moderately sorted.

66 cm unit: massive. The fresh surface color is pink. The sand grains are fine, well to sub-rounded, and moderately sorted.

Franklin Street; 3.2 miles from Pebbly intersection

Approximate lateral distance: 309 feet (94m)

Approximate vertical distance: 4 feet (1.5m)

Dominate facies: horizontal planar lamination and thin beds

Secondary facies and sedimentary features: ripple lamina, massive erosive bases

Summary: This outcrop is on the north side of the road. The basal units are amalgamated but grade vertically into discrete stacked sand units inter-bedded with unconsolidated sediments and mudrock. These stacked units are dominantly thin beds with both ripple lamina and massive internal structures. The outcrop thins into unconsolidated sediments at both the east and the west terminus. At 67 feet from the west, there are some westerly dipping foresets. At 90 feet from the west, the upper unit has an overall FUS with thin beds at the base which grade into lamina toward the top. At 227 feet from the western end, the outcrop is dominated by thin beds of planar lamina. The thin beds are approximately 13 cm each.

Vertical description: location is 207 feet from the western terminus.

Base: 63 cm friable horizontal planar lamina and very thin beds. Fresh surface is red in color. Sand grains are fine, sub-rounded, and moderately to poorly sorted.

83 cm unit: planar lamina FUS in thickness, erosive base. The fresh surface is red to pink in color. The sand grains are fine to very fine, well to sub-rounded, and moderately to poorly sorted.

Franklin Street; 4.3 miles from Pebbly intersection

Approximate lateral distance: 297 feet (90m)

Approximate vertical distance:

Dominate facies: Ripple beds and lamina

Sedimentary features present: erosive bases, planar lamina

Flow direction: east, northeast

Summary: This outcrop is on the north and the south side of the road. Within the northern outcrop there are foresets dipping to the east, north-east. The basal unit is erosive and down cuts into the underlying sediments. The outcrop on the south side of the road has an overall appearance that is both blocky and stacked sandstone units consisting of multiple thin beds with horizontal planar laminated internal structures. Both erosive and non-erosive bases are present.

Vertical description: location is approximately 98 feet from western end. The weathered surface is black in color. All sand grains are fine, sub-rounded, and moderately sorted unless otherwise noted.

Base: 31 cm unit with an erosive base and massive internal structure. The fresh surface is red in color.

31 cm unit: erosive base, ripple laminated at base gradating into massive vertically. The fresh surface is pink to orange in color.

46 cm unit: erosive base, massive with a fresh surface color of red.

60 cm unit: erosive base and ripple lamina. Sand grains are moderately sorted at base but become well sorted through upper half of this unit. The fresh surface is white to buff in color.

46 cm unit: erosive base and ripple lamina with a fresh surface of white to buff.

61 cm unit: erosive base. Foresets dipping to the west are present. Fresh surface color is pink to orange.

31 cm unit: massive at the base becoming laminated through uppermost 5 cm. Fresh surface color is red.

Pebbly Road; 2.4 miles north of Little Axe park entrance

Approximate lateral distance: three outcrops from south to north, 127 feet (39m), 86 feet (26m), and 104 feet (32m)

Approximate vertical distance: 2feet to 15 feet (<1m to 4.5m)

Dominate facies: horizontal planar lamina and thin beds

Secondary facies and sedimentary features: ripple lamina, massive, erosive bases,

Summary: Within this area are three discrete outcrops which will be examined independently. All outcrops are on the east side of the road. I will be discussing them in an order of south to north

Vertical description: outcrop A. This outcrop's overall description is that of stacked units separated by mudrock. Measurements are from the south end of the outcrop. The location is 76 feet from the south.

Base: 35 cm of unconsolidated sediments

50 cm unit: erosive base, planar horizontal lamina. Fresh surface color is red. Sand grains are upper fine, rounded, and moderately sorted.

63 cm of unconsolidated sediments

41 cm unit: horizontal planar laminated very fine grained sandstones, friable

17 cm unit: massive. Sand grains are lower fine to upper medium, rounded, and moderately sorted.

2 cm of mudrock

2.7 meter unit: multiple stacked thin beds (approximately 10 to 12). The basal 1 meter is massive with the other two units being dominated by ripple lamina. The sand grains FUS with lower fine transitioning into upper fine. All sands grains are rounded and moderately sorted. The fresh surface is pink to red in color.

Vertical description: outcrop B. This outcrop is composed of massive sand units aggrading to the north.

Base: massive, 25 cm measured above the surface but unit also extends into the subsurface. The sand grains are medium, rounded and moderately sorted.

8 cm of mudrock

43 cm unit: erosive base with massive internal structure along with intermittent traces of planar lamina. The sand grains are lower medium, rounded, and moderately sorted.

Vertical description: outcrop C. This outcrop is the furthest northern location. This outcrop has been heavily planed to a low angle by the highway department. It extends to within a few feet of the road and floors the drainage ditch.

Base: extends into the subsurface and floors the drainage ditch. It extends vertically above the ground for 38 cm. It is massive and its fresh surface is red in color. The sand grains are low medium, rounded, and moderately sorted.

40 cm unit: internal ripple lamina. The sand grains are upper fine, rounded, and moderately sorted.

44 cm unit: internal ripple lamina. Moderate amount of dark grains are present. The fresh surface is red in color. The sand grains are upper fine, rounded, and moderately sorted.

6 cm unit: massive. Fresh surface is buff in color. Sand grains are upper fine, rounded and moderately sorted.

Pebbly Road; 2.6 miles north of Little Axe park entrance

Approximate lateral distance: 100 feet (30.5m)

Approximate vertical distance: 3.5 feet (1m)

Dominate facies: massive

Secondary facies and sedimentary features: ripple lamina, horizontal planar lamina

Summary: This outcrop is on the west side of the road. Toward the south it becomes discontinuous and becomes increasingly horizontal to the ground's surface

Vertical descriptions: location is at 50 feet.

Base: 40 cm above ground but extends into the subsurface. It is massive throughout lower 22 cm transitioning into planar horizontal lamina. The fresh surface is red in color with a moderate amount of dark grains being present. The sand grains are upper-fine to fine, rounded, and moderately sorted.

42 cm unit: massive. Sand grains are fine, rounded, and moderately sorted.

18 cm unit: ripple lamina. The fresh surface is orange in color. The sand grains are fine, rounded, and moderately sorted.

Pebbly Road; 2.8 miles north of Little Axe park entrance

Approximate lateral distance: 54 feet (16m)

Approximate vertical distance: 5.5 feet (1.5m)

Dominate facies: massive

Secondary facies and sedimentary features: ripple lamina

Summary: This outcrop is on both the west and the east side of the road with each having an approximate lateral distance of 54 feet. The following is a general description of the overall outcrop. The eastern outcrop is positioned somewhat further to the south than its continuation on the west side of the road.

East: measuring from the south, from 0 to 27 feet it is discontinuous sandstone units. From 27 to 54 feet the sandstone is laterally continuous. Within the continuous sand units, the sandstone unit floors the drainage ditch and extends 1.09 meters above the surface. It has a massive internal structure with dark grains present. The fresh surface is buff in color. The sand grains are very fine, rounded and moderately sorted. This is overlain by a 55 cm unit of ripple lamina. The sand grains are fine grained, rounded and moderately sorted. Again, the fresh surface is buff in color and dark grains are present. There is a thin shale layer, < 20 mm, separating the two.

West: This outcrop is of the same description as the eastern side but is only one sandstone unit. It is massive with discontinuous ripple laminations. The sand grains are fine, rounded and moderately sorted. This outcrop is more fractured that the one on the east side of the road.

Pebbly Road; 3.1 miles north of the Little Axe park entrance

Approximate lateral distance: 315 feet (96m)

Approximate vertical distance: 3 feet (1m)

Dominate facies: horizontal planar lamina

Secondary facies and sedimentary features: massive, ripple lamina, erosive bases, planar cross lamination

Summary: This outcrop is on the east side of the road but also extends to the west side. All measurements are taken from the south end to the north. Referring to the eastern outcrop, laterally it is sandstone dominated from 0 feet to 175 feet. From 175 feet to 315 feet it is dominated by very friable sand rich mudrock with medium grain sand grains. As previously stated the outcrop extends to the west side of the street and has a similar description except that it has a lesser quantity of sandstones.

Vertical description: location is on the east side of the road at approximately 35 feet.

Base: 44 cm unit; low angle planer laminations dipping to the north and truncated by the overlying unit

23 cm unit; erosive base, horizontal planar lamina

Both are of upper-fine grains, rounded. and moderately sorted. The fresh surface is red in color and the units are somewhat friable

Vertical description: location is on the east side of the road at approximately 115 feet.

Base: 30 cm weathered sand rich mudrock

18 cm unit: Approximately three thin beds with massive internal structure. The fresh surface color is red. The sand grains are medium, rounded, and moderately sorted. This unit is firm-slightly friable

14 cm very friable medium grained lamina

40 cm unit: planar laminations throughout basal 26 cm transitioning into thin beds with massive internal structure. The fresh surface color is red. The grains are medium, rounded, and moderately sorted. Vertically, the sand grain size FUS from medium into fine remaining rounded and moderately sorted. This unit is firm-slightly friable.

Vertical description: location is on the east side of the road at approximately 153 feet

Base: this sandstone unit extends 25 cm above the surface but extends into the subsurface. It has a massive internal structure.

55 cm unit: erosive base and massive internal structure. The fresh surface color is buff. The sand grains are lower medium, rounded, and moderately sorted.

18 cm unit: thin beds with laminated internal structure. The fresh color is buff to pink. The sand grains are fine, rounded, and moderately sorted.

7 cm unit: friable planar lamina. The sand grains are upper fine grained, rounded, and moderately sorted.

9 cm unit: massive. The sand grains are upper fine, rounded, and moderately sorted. This unit is somewhat friable

Toward the north, the sandstone units thin and become discontinuous with planar cross-lamination. The grains are medium, rounded, and moderately sorted. This part of the outcrop is friable to slightly friable. The remaining lateral distance of this outcrop is dominated by very friable laminated medium grained mud rich sandstones.

Pebbly Road; 3.9 miles north of the Little Axe park entrance

Approximate lateral distance: 163 feet (50m)

Approximate vertical distance: 5 feet (1.4m)

Dominate facies: massive

Secondary facies and sedimentary features: ripple lamina

Summary: This outcrop is on the east side of the road and has been planed to approximately 45°. This outcrop does extend to the west side of the street but has the same general description as the east side. The only exception is that it is on the western side of the street it only 37 feet in approximate lateral distance. The following descriptions will be of the eastern outcrop. Overall, it has a weathered surface that is red and black in color. At the southern end it transitions into one 56 cm think unit with a massive internal structure with discontinuous ripple lamina through topmost 12 cm. There is a slight FUS of grain size from upper medium sand grains at base transitioning into upper-fine toward the top. Moderate amount of dark grains are present.

Lateral Measurements from north to south: 1 to 28 feet are thin and discontinuous sandstones; from 28 to 59 feet is sandstone dominated; from 59 to 85 feet is unconsolidated material; from 85 to 108 feet is sandstone dominated; from 108 to 133 feet it is dominated by unconsolidated material with one sandstone three feet in lateral distance; from 133 to 151 feet it is sandstone dominated; the remainder of the outcrop is discontinuous.

Vertical description: location is approximately 100 feet from the north.

Base: 1 meter thick massive unit. The fresh surface is buff-pink gradating into red and red-orange. Moderate amount of dark grains are present. Sand grains are medium, rounded, and moderately sorted.

40 cm unit: medium beds with ripple laminated internal structure. Sand grains are medium, rounded, and moderately sorted.

Vertical description: location is approximately 45 feet from the north.

Base: 17 cm unit with an internal structure of ripple lamina. The fresh surface is buff-pink in color. The sand grains are medium, rounded, and moderately sorted.

30 cm unit: ripple lamina. The fresh surface color is buff-pink. The sand grains are lower medium to upper fine, rounded, and moderately sorted.

25 cm unit: ripple lamina. The fresh surface is orange-buff in color. The sand grains are upper fine to lower medium, rounded, and moderately sorted.

Pebbly Road; 4.6 miles north of Little Axe park entrance, south side of Bethel Road intersection

Approximate lateral distance: 263 feet (80m)

Approximate vertical distance:

Dominate facies: Massive

Secondary facies and sedimentary features: planar horizontal lamina, ripple beds and lamina

Summary: This outcrop is on the west side of the road. The measurements are taken from the north. Overall, this outcrop is discontinuous sand sandstones separated by unconsolidated sediments both laterally and vertically. I estimate that the unconsolidated material represent approximately 85% of the total area.

Vertical description: location is at 96 feet from the northern terminus.

Base: 1.5 meters of covered slope

34 cm unit: sandstone with an internal structure of ripple lamina

Remainder is covered slope

Vertical description: location is at 125 feet.

Base: 64 cm covered slope

1.5 meter unit: mostly massive with ghost planar and ripple lamina. The sand grains have a slightly CUS from fine at the base to upper-fine, lower-medium toward the top. They are rounded and moderately sorted throughout.

Vertical description: located at 210 feet and consists of two stacked units.

Base: 33 cm horizontal planar lamina. Sand grains are fine, rounded and moderately sorted.

43 cm unit: planar laminations transitioning into ripple lamina throughout topmost 15 cm. The sand grains are fine, rounded, and moderately sorted.

Pebbly Road; 4.9 miles north of Little Axe park entrance

Approximate lateral distance: 163 (50m) and 303 feet (92m), east and west side of the road respectfully

Approximate vertical distance: East side, north end of the outcrop, 5.4 feet (1.6m)

Dominate facies: mudstone

Secondary facies and sedimentary features present: rippled beds and lamina, carbonate clast conglomerate, shale and laminated siltstones, trough cross beds

Flow direction: 37° (parting lineations) NE (foresets)

Summary: This outcrop exists on both sides of the road. On the eastern side of the road the outcrop is a combination of sandstone units and thin to medium beds of carbonate clast conglomerates. Toward the northern end are approximately seven thin stacked units with possible (poorly defined) trough cross beds. The internal structure of each is dominated by ripple lamina. The top-most unit however is of planar horizontal thin beds with an internal structure of ripple lamina. Also within the sandstone units are low angle planar laminations and foresets dipping to the northeast along with massive internal structure. Ripple lamina is very prevalent throughout. Within this eastern outcrop there are sandstone units that are gray in color and strongly cemented. They are discontinuous and surrounded by unconsolidated mud rich sand. It should be noted that within my study area, strongly cemented sandstones are the exception rather than the rule. The beds of carbonate clast conglomerates are also discontinuous and vary in thickness of approximately 15 cm to 37 cm. Measuring from the north at approximately 156 feet, a bed of carbonate clast conglomerate, approximately 20 cm thick, exhibits cross-lamination and possibly rippled lamination. Also noted at the southern end at the very top of the outcrop are quartzite and cert gravels and cobbles.

The outcrop on the western side of the road is very weathered and toward the north is dominated by mudstone. Where sandstone exists, it has a planar laminated internal structure with only minor ripple lamina. Truncation and cross-cutting relationships are noted throughout the outcrop. There is a sandstone unit at approximately 149 feet from the south that is strongly cemented and gray in color. The carbonate clast conglomerates on this side of the road are less dominate and more weathered. There is one distinct channel which is downcutting into shale and laminated siltstones of which I interpret as over-bank deposits. The channel trough sandstone is a CUS with an erosive base transitioning from thin into medium beds. The sand grain size is fine, sub-rounded and moderately sorted.

Vertical description: location on the eastern side of the road at approximately 65 feet measured from the north. These are stacked poorly defined but possibly trough cross bedded sandstone units.

Base: Above a covered slope is a 45 cm unit. It has a massive internal structure with discontinuous ripple lamina. The sand grains are upper fine, sub-rounded, and moderately sorted.

76 cm unit: thin beds throughout basal 15 cm then transitioning into massive. Discontinuous rippled lamina is also present. The weathered surface is pink and black in color while the fresh surface color is pink. Sand grains are upper-fine, sub-rounded and moderately sorted.

61 cm unit: mostly massive with ghost ripple lamina throughout. The sand grains are fine, rounded, and moderately sorted.

40 cm unit: ripple laminated. Fresh surface color is buff in color. Sand grains are very fine, rounded and moderately-well sorted.

Vertical description: on the west side of the road near the far northern terminus

Approximately 1.5 meters of mudstone. This area is weathered clay sized grains without internal structure. The presence of soil formation indicators found include glaebules, rhizocretions, slickensides, and occasional caliche clasts.

Pebbly Road; 5.2 miles north of Little Axe park entrance

Approximate lateral distance: 100 feet (30.5m)

Approximate vertical distance: 11 feet (3.6m)

Dominate facies: Carbonate clast conglomerate

Secondary facies and sedimentary features: low angle planar lamina, ripple lamina, massive

Summary: This outcrop is on the west side of the road with a drive dissecting its terminal southern end. This drive is a very good place to park. This outcrop exhibits two areas of iron stone with marked differential weathering from the surrounding weakly cemented sandstones. The areas of iron stone are dark purple in color and easily seen. There is also a unit, approximately 1.7 meters thick, at the uppermost area of the outcrop. It is made-up of thin to medium beds of carbonate clast conglomerates. Within the sandstone units are intermittent low angle ghost lamina and ripple lamina. Weathered surface is dominantly black in color.

Vertical description: location is at 52 feet from the south.

Base: 61 cm covered slope

19 cm unit: ripple lamina. The fresh surface is orange to buff in color. The sand grains are fine, rounded. and moderately sorted.

51 cm unit: planar low-angle lamina dipping to the north. Fresh surface color is white. Sand grains are fine, rounded, and moderately-well sorted.

19 cm unit: massive. Fresh surface color is white. Sand grains are fine, rounded, and moderately-well sorted. This unit is separated from the lower unit by differential weathering.

45 cm covered slope consisting of both unconsolidated sediments and finely laminated mud rich siltstones.

1.7 meter unit: thin to medium beds of very strong, well cemented carbonate clast conglomerate.

Pebbly Road; 5.4 miles north of Little Axe park entrance, across from Stella Cemetery

Approximate lateral distance: 260 feet (80m)

Approximate vertical distance: 6 feet (1.9m)

Dominate facies: massive

Secondary facies and sedimentary features: ripple lamina, planar horizontal thin beds, erosive bases

Summary: This outcrop is on the west side of the road. All measurements are taken from the south. Laterally, from 0 to 70 feet the outcrop is discontinuous blocky sandstones. I estimate that the sandstone units are approximately 20% of the total surface area. Continuous sandstone is present from 74 to 260 feet with the northern most 140 feet being planed. These are stacked units with a combination of erosive bases and differential weathering. Very thin to thin beds with planar laminated internal structure is present along with massive bedding. Minor ripple laminations can also be seen.

Vertical description: location is 181 feet. This is the same section that the gamma ray was obtained by G. Gromadzki. It consists of two stacked sandstone units.

Base: 1.4 meters sandstone unit which is mostly massive with the exception of a small number of planar horizontal thin beds seen toward the middle of the unit. The weathered surface is black in color while the fresh surface is red in color. The sand grains are fine, rounded, and moderately sorted.

50 cm unit: massive transitioning into ripple laminations throughout the top 18 cm. The sand grains are fine, rounded and moderately sorted.

Pebbly Road; 6 miles north of the Little Axe park entrance

Approximate lateral distance: 382 feet (116m)

Approximate vertical distance: 23 feet (7m)

Dominate facies: massive

Secondary facies and sedimentary features: shale and laminated siltstones, low angle planar laminations, erosive bases, truncation, foresets

Flow direction: 30° (strike-dip of low angle beds); 31° (foresets – possibly small accretionary bars

Summary: This outcrop is on the east side of the road and consists of very thick or amalgamated sandstone units. Erosive bases are common with good examples of truncation. Foresets dipping to the north-northeast are also present. At the northern end of this outcrop the channel margin is well defined with an erosive base down-cutting into the underlying shale and laminated siltstones.

Vertical description: location is approximately 286 feet from the north. This is the same vertical section where the gamma ray was obtained by G. Gromadzki.

Base: extends into the subsurface with 17 cm above ground. This sandstone unit has a laminated internal structure and the sand grains are fine, sub-rounded and moderately sorted.

19 cm low angle, mud dominated low angle sandstone laminations dipping to the south but they become more horizontal as one moves vertically. The sand grains are fine, sub-rounded. and poorly sorted.

71 cm unit: massive throughout the basal 42 cm transitioning into very thin beds with foresets dipping to the northeast. The topmost 7 cm is horizontally planar laminated and very thin beds.

Sharp contact: I can not definitively say if this is a very thin shale layer or a contact of differential weathering.

6 meter unit: erosive base with massive internal structure. There are also multiple joints present. The fresh surface color gradates form white throughout the lower half into red for the remainder.

180^{th} NE Street; 0.2 miles north of the Hwy 9 intersection

Approximate lateral distance: 94 feet

Approximate vertical distance: 7 feet (2.2m)

Dominate facies: horizontal planar thin beds and lamina

Secondary facies and sedimentary features: massive, erosive bases

Summary: This outcrop is on the west side of the street, immediately north of 1300 N 180^{th} driveway. Overall, this outcrop is composed of 4 stacked units with a FUS in relation to unit thickness. Grain size decreases from medium throughout the southern regions but become very fine toward the north. This outcrop is highly weathered and the internal structure is difficult to distinguish. Each unit has an erosive base down-cutting into the underlying unit. The weathered surface is black and red with the fresh surface being red in color. Measurements are from the south.

Vertical description: location is at approximately 47 feet from the south.

Base: 1.2 meters sandstone with an internal structure of horizontal planar thin beds. This unit lacks an erosive base and appears to extend into the subsurface. The sand grains are medium, rounded. and well sorted.

60 cm unit: planar horizontal thin beds. The sand grains are medium, rounded, and well sorted.

30 cm unit: massive. Sand grains are medium, rounded, and well sorted.

15 cm unit: massive. Sand grains are medium, rounded, and well sorted.

180^{th} NE Street; 0.9 miles north of Hwy 9 intersection

Approximate lateral distance: 236 feet (72m)

Approximate vertical distance: 5.5 feet (1.75m)

Dominate facies: massive

Secondary facies and sedimentary features: ghost trough cross beds, low angle and horizontal planar laminations, erosive bases

Flow direction: parting lineations, 302°

Summary: This outcrop is on west side of the road. Overall, this outcrop is one of stacked channels which become discontinuous northward. I estimate that sandstone represents approximately 60 to 70% of the surface area. The fresh surface does not react with dilute HCL however the weathered surface does react positively in places.

Vertical description: location is the southern end of the outcrop.

Base: 15 cm sandstone unit with a massive internal structure and extends into the subsurface. The sand grains are medium, rounded, and moderately sorted.

45 cm unit: erosive base. Massive internal structure with ghost trough cross-bedded laminations transitioning into low angle and planar horizontal laminations toward the top

33 cm unit: massive, very friable

30 cm unit: Massive at base transitioning into planar horizontal lamina at top

Vertical description: location is approximately 43 feet. This is the area where the gamma ray was obtained by G. Gromadzki.

Base: 62 cm sandstone unit with massive internal structure and extends into the subsurface. The sand grains are medium, sub-rounded, and moderately sorted.

60 cm unit: massive with an erosive base. Sand grains are medium at base FUS into fine grained toward top.

32 cm unit: massive. The sand grains are medium, sub-rounded, and moderately sorted.

30 cm unit: laminated. The sand grains are very fine, rounded and moderately sorted.

180th NE Street; 1.3 miles north of Hwy 9 intersection

Approximate lateral distance: 130 feet (40m)

Approximate vertical distance: 2 feet (0.7m)

Dominate facies: ripple lamina

Secondary facies and sedimentary features: massive, erosive bases,

Summary: This outcrop is on west side of the road and is dominated by unconsolidated sediments with only discontinuous sandstone units. Measurements are taken from the south. Laterally, from 0 to 16 feet the sediments are a deep purple in color. At approximately 103 feet there is an area of ghost cross lamination.

Vertical description: location is at approximately 5 feet. There are iron stains and banding present. This is the area where the gamma ray was obtained by G. Gromadzki.

Base: 11 cm massive sandstone unit that extends into the subsurface. The sand grains are medium, sub-rounded and moderately sorted.

20 cm unit: erosive base with internal ripple lamina throughout. The sand grains are medium, sub-rounded, and moderately sorted.

10 cm unit: has an erosive base and has an internal structure of ripple lamina. The sand grains are medium, sub-rounded and moderately sorted.

2 cm unconsolidated mud rich sediments

10 cm unit: ripple lamina. The sand grains are medium, sub-rounded and moderately sorted.

Vertical description: location is at approximately 28 feet. This is one sandstone unit of 73 cm which is massive at the base but transitioning into ripple lamina. The sand grains are fine, sub-rounded and moderately sorted. This is capped by approximately 80 cm of covered slope.

180th NE Street; 1.4 miles north of Hwy 9 intersection

Approximate lateral distance: 175 feet (53m)

Approximate vertical distance: 5.5 feet (1.7m)

Dominate facies: massive

Secondary facies and sedimentary features: horizontal planar lamina, trough cross lamina, planar cross lamina, ripple lamina, erosive bases

Summary: This outcrop is on the west side of the road. Overall, this outcrop is stacked sand units separated by unconsolidated sediments. The sandstones have a weathered surface that is pink and red in color with smaller areas of white and black. One area is artificially planed but the remainder is experiencing natural weathering response. At approximately 151 feet there is a 10 cm band of foresets dipping to the south – southwest. All measurements are from the southern end of the outcrop.

Vertical description: location is approximately 27 feet.

Base: 42 cm of horizontal planar lamina throughout basal 23 cm then transitioning into ripple lamina. Sand grains are fine, sub-rounded, and poorly sorted.

37 cm of unconsolidated slope

49 cm unit: massive for lower 42 cm then transitioning into thin beds

44 cm unit: erosive base. Internal structure is massive with ghost planar laminations.

Vertical description: location is at approximately 49 feet from the south.

Base: 32 cm unit of ripple thin beds

1 meter thick unit of medium horizontal planar beds and thin beds without a CUS or FUS, erosive base

Vertical description: location is at approximately 81 feet from the south.

Base: 120 cm massive unit with discontinuous ghost trough cross lamina and planar cross lamina. Sand grains are medium.

To the north, is some differential weathering around resistant iron stone.

180th NE Street; 2.7 miles north of Hwy 9 intersection

Approximate lateral distance: 159 feet (48.5)

Approximate vertical distance: 20 feet (6m)

Dominate facies: massive

Secondary facies and sedimentary features: horizontal planar thin beds / lamina, discontinuous erosive bases, planar low angle planar cross beds (small accretion bars?).

Summary: This outcrop is on both the west and east side of the road. The outcrop extends into the subsurface with horizontal to low and planar lamina and what are possibly small accretion bars in the basal 3 feet (approximate). This transitions into massive which transitions into horizontal planar thin beds and lamina in the upper portion of the outcrop. It the lower part of the overall outcrop, weathered out mud layers give the impression of partial and discontinuous erosive channel bases. However, within the massive portion of this outcrop, weathering and an artificially planed surface makes unit differentiation and internal structure identification difficult.

Vertical description: East side of the road

Base: approximately 460cm sandstone unit extending into the subsurface with horizontal to low angle planar laminations with a band of planar cross beds (small accretion bars?) dominating the basal 1 meter. This unit transitions into massive without a distinct bounding surface. There are also weathered out very thin mud layers that give the impression of partial and discontinuous erosive channel bases. The weathered surface is black and to a lesser degree red. The fresh surface is white to buff in color. The sand grains are fine in size and moderately sorted

140 cm unit: horizontal planar thin beds and lamina, dominantly red in color. The grain size fines upward from fine grained to very fine / silt at top.

Harra-Newalla Road; 0.7 miles north of Hwy 9 intersection

Approximate lateral distance: 210 feet (64m)

Approximate vertical distance: 14 feet (4m)

Dominate facies: horizontal planar thin beds and lamina

Secondary facies and sedimentary features: erosive bases, massive, trough cross-beds and lamina, ripple lamina

Summary: This outcrop is on the west side of the road. It is dominated by stacked sandstone units separated by unconsolidated sediments. Erosive bases are present and, overall, planar laminations and thin beds dominate. The weathered surface is dominantly black while the fresh surface is red in color unless otherwise stated. Most sand grains are fine to very fine, sub-rounded, and moderately sorted. Measurements are from the south end of the outcrop.

Vertical description: location is approximately at 107 feet from the south.

Base: 61 cm of covered slope

39 cm unit: erosive base with massive internal structure. The fresh surface is orange in color. The sand grains are upper fine, sub-rounded, and moderately sorted.

40 cm unit: erosive base massive thin to very thin beds. The sand grains are medium, sub-rounded, and moderately sorted.

2 meter unit: erosive base, internal structure of planar horizontal lamina gradating into trough cross-lamina and trough cross-beds throughout upper 50 cm. There is a moderate amount of dark grains present. The sand grains are upper fine, sub-rounded, and moderately sorted.

46 cm unit: massive with cross lamina. The sand grains are upper fine, sub-rounded, and moderately sorted.

34 cm unit: massive. The sand grains are lower-medium to upper fine, sub-rounded, and moderately sorted.

17 cm unit: ripple lamina. The sand grains are upper medium, sub-rounded, and moderately sorted.

Harra-Newalla Road; 1.3 miles north of Hwy 9 intersection

Approximate lateral distance: 40 feet (14m) and 71 feet (22m), southern and northern outcrop respectfully

Dominate facies: low angle planar thin beds

Secondary facies and sedimentary features: erosive bases, massive, planar cross-beds, foresets, ripple lamina, trough cross-beds

Flow direction: Foresets dipping to the north-northeast

Summary: There are two outcrops a few hundred feet from each other. Both are on the west side of the road. G. Gromadzki obtained his gamma reading from the northern outcrop. The southern outcrop is 4 sandstone units. The basal unit is mostly horizontal whereas the overlying three units are high angle (approximately 40°) aggrading to the north. These units are each separated by unconsolidated sandy sediments. At the southern end of this outcrop there are thin beds present as well as massive internal structures. The sand grains are medium to upper fine, sub-angular, and poorly sorted at the base while becoming moderately sorted as one moves upward through the outcrop. The northern end of the same outcrop has low angle planar cross lamina with truncation, low angle planar thin beds. and foresets dipping to the north-northeast. The sand grains are lower medium at the base transitioning into upper fine toward middle, then returning to lower medium toward top.

The northern outcrop has an erosive base toward the south but the base extends into the subsurface from 37 feet (measured from the south) northward. The apex is at approximately 39 feet from the south. Internal structure is overall low angle thin beds and trough cross-beds with an erosive base. The thin beds are dipping to the south-southeast at the southern end of this outcrop. At approximately 39 feet measuring from the south, are planar low angle thin beds dipping to the south becoming horizontal toward the top. Planar cross-bedding is present at the base. There is a moderate amount of dark grains present. The sand grains FUS from lower medium at the base to fine at the top. Internal structure becomes massive northward.

Harra-Newalla Road; 1.5 miles north of Hwy 9 intersection

Approximate lateral distance: 244 feet (74m)

Approximate vertical distance: 8 feet (2.5m)

Dominate facies: massive

Secondary facies and sedimentary features: ripple thin beds and lamina, erosive bases,

Summary: This outcrop is on the east side of the road. The southern part of the outcrop is composed of a continuous sandstone body while the northern part is dominated by blocky highly fractured sandstones and mudrock giving it a 'bad lands' appearance.

The southern continuous sandstone body thins and becomes discontinuous toward the south. It extends northward approximately 167 feet where it thins only slightly then terminates into unconsolidated sediments. Positioned above this continuous sandstone's northern terminus is the southern terminus of the blocky highly fractured sandstone unit.

All measurements are from the south.

Vertical description: location is at approximately 116 feet from the south.

Base: 1 meter above the surface but also extends into the subsurface. This unit is mostly massive transitioning into ripple lamina throughout top 18 cm. However, weathering effects and the angle of the sun makes it difficult to be definitive. The sand grains are upper fine at the base FUS into very fine and silt towards the top. Dark grains become more prevalent toward the top also. The sand grains are rounded and moderately sorted.

1 meter of silt dominated unconsolidated sediments

30 cm unit: The basal 10 cm is of very fine grained purple sandstone transitioning into very fine grained lamina / siltstone interbedded with silt rich unconsolidated sediments.

45 cm unit: massive, very friable, very fine moderately sorted

Vertical description: location is at approximately 164 feet from the south.

Base: this sandstone unit extends into the subsurface and measures 72 cm above the surface. The basal 15 cm is massive transitioning into ripple lamina and rippled thin beds.

18 cm of covered slope

11 cm unit: massive, erosive base. The sand grains are lower-fine. sub-rounded, and moderately sorted.

24 cm unit: very thin beds transitioning into thin beds with the uppermost 13 cm being low angle planar thin beds dipping toward the north

23 cm unit: massive, erosive base. There is a small discrete area of ripple lamina at the very top. The grains are lower medium to upper fine, sub-rounded, and moderately sorted.

1.2 meters of unconsolidated sediments

Vertical description: location is at approximately 198 feet from the south. This area is highly eroded and has a 'bad lands' appearance. The blocky highly fractured sandstone unit at the base has a sharp contact with the overlying weathered, mudrock.

Base: 1 meter of blocky sandstone. This blocky sandstone has an erosive base toward the northern terminus that is not seen toward the south. The grains are upper fine, rounded, and moderately sorted.

1.2 meters mudrock

Harra-Newalla Road; 1.6 miles north of Hwy 9 intersection

Approximate lateral distance: 198 feet (60m)

Approximate vertical distance: 6 feet (1.9m)

Dominate facies: ripple thin beds and lamina

Secondary facies and sedimentary features: massive, erosive bases

Flow direction:

Summary: This outcrop is on the east side of the road. The northern end thins into unconsolidated sediments whereas toward the south it becomes discontinuous before thinning into unconsolidated sediments. This outcrop is highly weathered. Measurements are taken from the south.

Vertical description: location is at approximately 43 feet from the south

Base: 30 cm massive unit with erosive base. The weathered surface is black and pink in color while the fresh surface is pink to buff. The sand grains are upper fine, sub-rounded, and moderately sorted.

58 cm unit: Ripple thin beds at base transitioning into ripple lamina toward top. The sand grains are lower fine at base transitioning into upper fine vertically. They are sub-rounded and moderately sorted throughout.

1 meter unconsolidated sediments

Vertical description: location is at approximately 117 feet from the south. This is the area G. Gromadzki obtained the gamma reading. These sandstone units are stacked with erosive bases. The weathering surface is black in color while the fresh color is pink to buff.

Base: 26 cm with ghost planar lamina. The sand grains are lower medium, sub-rounded, and moderately sorted.

36 cm unit: massive with discontinuous ripple thin beds toward top. The sand grains are lower-medium, sub-rounded, and moderately sorted.

69 cm unit: massive with a FUS with medium beds transitioning into thin beds then into lamina. The sand grains are upper-fine, sub-rounded, and moderately sorted.

60 cm unit: basal planar laminations transitioning into ripples and planar cross lamina throughout uppermost 23 cm. There is also an isolated area (approximately 20 cm) of trough cross lamina. The sand grains are upper fine, sub-rounded, and moderately sorted.

Harra-Newalla Road; 2.1 miles north of Hwy 9 intersection

Approximate lateral distance: 373 feet (113m) and 424 feet (129m), east and west side of the road respectfully

Approximate vertical distance: 6.5 feet (2m)

Dominate facies: horizontal to low angle planar thin beds and lamina

Secondary facies and sedimentary features: massive, ripple thin beds and ripple lamina, erosive bases.

Summary: This outcrop is on both sides of the road and will be referred to individually as east and west. The eastern outcrop is planed and very weathered making internal structure and individual units difficult to distinguish. Overall, the weathered surface is black in color.

The eastern outcrop: Toward the south it ends abruptly into unconsolidated sediments but to the north it thins before terminating into unconsolidated sediments. Stacked units are separated by very friable shale / laminated siltstones and unconsolidated sediments. Blocky sands are also present.

The western outcrop: At approximately 109 feet from the southern terminus it is dissected by Wolff Road. North of Wolff Road the outcrop becomes dominated with highly fractured blocky massive sandstones with erosive bases and sedimentary features found include planar thin beds and lamina, cross-beds, ripple lamina, and rippled thin beds. The outcrop south of Wolff Road is similar in depositional features to that of the eastern outcrop.

Vertical description: location is approximately 224 feet from the south terminus, eastern side. This is the area G. Gromadzki obtained his gamma readings.

Base: 60 cm unit extends into the subsurface; ghost planar lamina throughout. The sand grains are upper fine, sub-rounded, and moderately sorted.

55 cm unit: erosive base with massive internal structure. The sand grains are upper fine, sub-rounded, and moderately sorted.

164 cm unit: erosive base with planar thin beds throughout basal 10 cm transitioning into massive with traces of discontinuous ghost planar lamina then into planar thin bed toward the top. The sand grains are fine, sub-rounded, and moderately sorted.

18 cm unit: massive. Sand grains are upper fine, sub-rounded, and moderately sorted.

Vertical description: location is on the western side of 180th NE, approximately 300 feet from the south; north of Wolff Road.

Base: 60 cm of covered slope transitioning into sand rich mudstones.

27 cm unit: horizontal planar thin beds with internal planar lamina. The sand grains are fine, sub-rounded, and moderately sorted.

17 cm unit: thin to medium cross beds with internal lamina dipping to the north and truncated by the overlying unit. The sand grains are fine, sub-rounded and moderately sorted.

30 cm unit: planar medium beds with internal lamina. The sand grains are fine, sub-rounded and moderately sorted.

Harra-Newalla Road; 2.4 miles north of Hwy 9 intersection

Approximate lateral distance: 376 feet (114m) and 554 feet (169m), east and west side of the road respectfully

Approximate vertical distance: 16 feet (5m)

Dominate facies: ripple thin beds and lamina

Secondary facies and sedimentary features: horizontal planar thin and medium beds, low and high angle planar thin beds and lamina, wavy thin to medium beds, trough cross-beds, erosive bases

Summary: This outcrop is on both sides of the road and will be referred to as east and west. All measurements are from the south.

Eastern outcrop – From 0 to 76 feet unconsolidated sediments dominate with sandstone units being discontinuous. I estimate that the sandstone is < 20% of total surface area within this measurement. Continuous sandstone extends from 76 to 320 feet. Due to the planed and weathered surface, differentiation of individual sandstone units and their internal structure is difficult to determine. Overall, erosive bases dominate and thin ripple beds transition vertically into thin planar beds. Also present throughout the lower half of this area from 242 to 289 feet are high angle planar thin beds dipping to the south. From 227 feet is a unit of 5.5 meters continuous sandstone which also extends into the subsurface. However, as one moves toward the north, an erosive base can be seen. This sandstone is massive at the base transitioning into ripple thin to medium low angle beds. These then gradate into wavy thin to medium horizontal beds. There is no distinct FUS or CUS in relation to bed size. Grains are a FUS from upper fine and lower medium at the base to lower fine and very fine towards the top. From 289 to 376 feet laterally, the sandstones become discontinuous.

Western outcrop – This is a continuation of the outcrop found on the east side with similar structures and grain size. The following is a list of what is found unique to the western side. All measurements are from the south terminus. At approximately 172 feet from the south at the upper-most part of the outcrop/slope are medium sized trough cross-beds with a grain size of upper fine. At approximately 431 feet from the south there are ghost trough cross-laminations throughout an entire 1 meter thick unit. This sandstone also has an erosive base.

Vertical description: one continuous sand body of approximately 5 meters. It extends into the subsurface and has a massive internal structure throughout the lower 3.75 meters, approximately. Along this measurement, the internal structure transitions into ripple lamina. However, I can not determine a definitive break within this overall sand unit. The sand grains are fine, sub-rounded, and moderately sorted.

104^{th} Street, a few hundred yards east of the Choctaw (120^{th}) – 104^{th} Street intersection.

Though out of the defined six transect study area, a description of this outcrop is offered because the lithofacies associations found at this site represents lateral facies change. Though not the only outcrop representing lateral facies change, it is the largest and has some sedimentary features not seen at the outcrops along the six transects. These features include a band of barite nodules that crosses the bounding surfaces of different units, some of the better examples of trough cross beds, and toward the eastern end there are discreet areas of violet / purple surface coatings that do not extend into the sandstones more than a millimeter or two. This is different from the iron stone formation seen at other outcrops. The following descriptions begin toward the western terminus and move eastward.

Description 1: the western end is approximately 3 meters vertically and dominated by low to high angle planar thin beds interbedded with unconsolidated sand rich sediments. There are also planar low angle cross beds. The grain size is very fine to silt. The sandstone units become increasingly friable toward the top of the outcrop. This area is interpreted to represent over bank deposits.

Description 2: the basal unit extends into the subsurface existing approximately 120cm above the ground surface. It is dominated by horizontal planar laminations. This unit is truncated by the over lying unit.

60cm: horizontal to low angle planar lamination with an erosive base. Sand grains are fine to lower medium, moderately sorted, and sub-rounded.

200cm: horizontal thick and thin beds without definitive FUS or CUS. These beds have a very thin mud drape at the bounding surface which is commonly weathered out.

Toward the east, the sediments become increasingly mud rich and there are discontinuous units of mudrock present.

Description 3: this is located near the middle of the overall outcrop, near the thickest portion. The basal unit is approximately 400cm and dominated by trough cross beds. Within this unit there is a discreet 90cm band of barite nodules crossing unit bounding surfaces and dipping to the west. There are also erosive bases present within this unit. This transitions into a 120cm unit of planar thin beds.

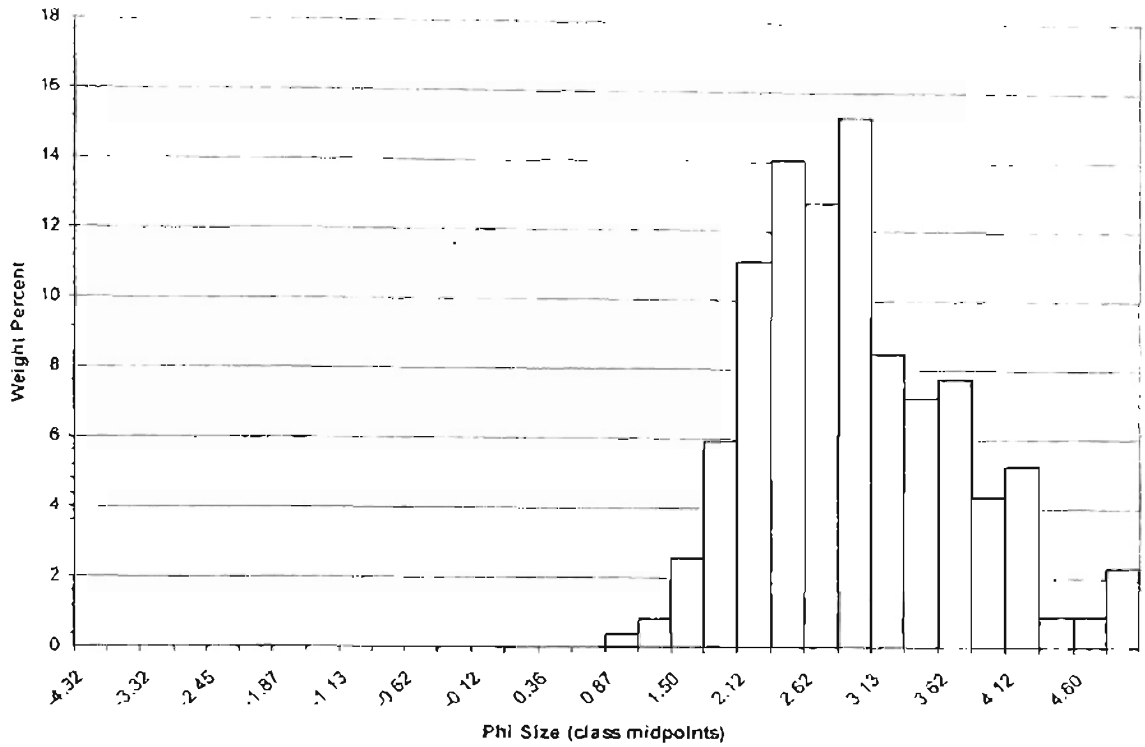
3.7 meters: trough-cross beds with numerous examples of truncation. This area transitions into an additional 76cm of planar horizontal thin beds and lamina.

Above the sandstone unit is approximately 1 meter of weathered mudrock.

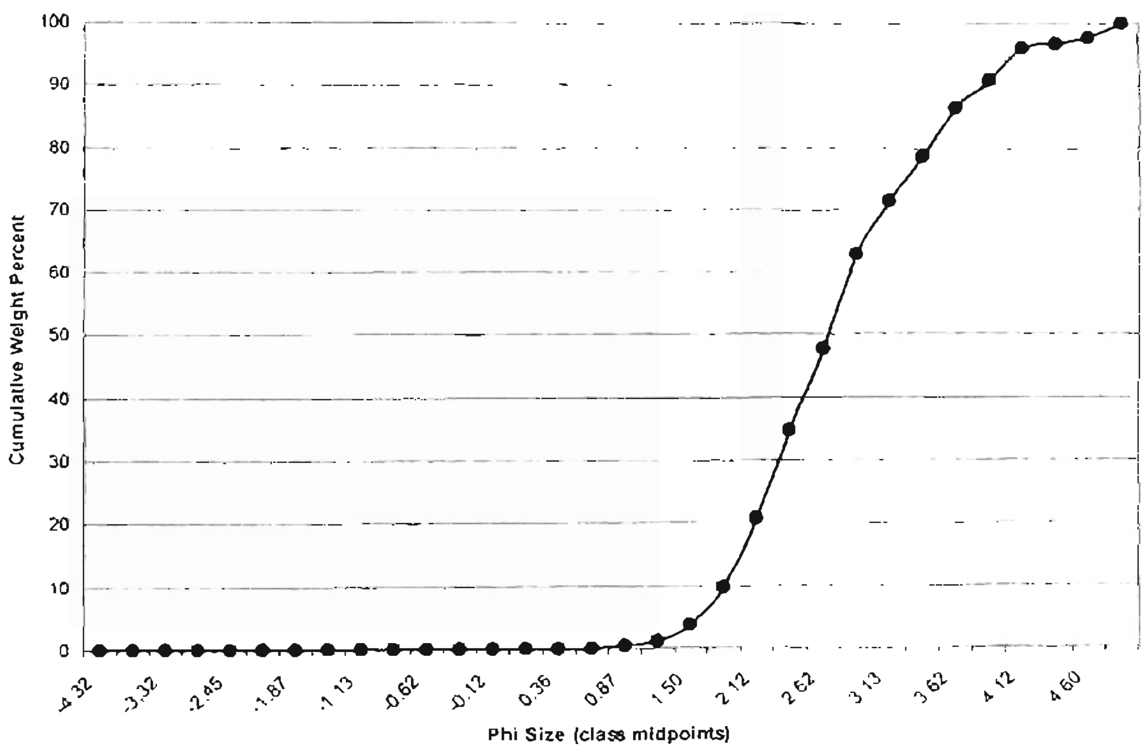
APPENDIX C

METHOD OF MOMENTS GRAIN SIZE ANALYSIS OF OUTCROPS FROM SIX TRANSECTS

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m - x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.88	47.36	0.00	-325.93	0.00
0.50	-3.82	0.00	0.00	0.00	-6.38	40.73	0.00	-259.93	0.00
0.50	-3.32	0.00	0.00	0.00	-5.88	34.60	0.00	-203.50	0.00
0.49	-2.83	0.00	0.00	0.00	-5.39	29.03	0.00	-156.39	0.00
0.38	-2.45	0.00	0.00	0.00	-5.01	25.12	0.00	-125.88	0.00
0.33	-2.12	0.00	0.00	0.00	-4.68	21.94	0.00	-102.76	0.00
0.25	-1.87	0.00	0.00	0.00	-4.43	19.66	0.00	-87.19	0.00
0.37	-1.50	0.00	0.00	0.00	-4.06	16.48	0.00	-66.91	0.00
0.37	-1.13	0.00	0.00	0.00	-3.69	13.58	0.00	-50.06	0.00
0.25	-0.87	0.00	0.00	0.00	-3.43	11.79	0.00	-40.50	0.00
0.25	-0.62	0.00	0.00	0.00	-3.18	10.13	0.00	-32.22	0.00
0.25	-0.37	0.00	0.00	0.00	-2.93	8.57	0.00	-25.08	0.00
0.25	-0.12	0.00	0.00	0.00	-2.68	7.18	0.00	-19.24	0.00
0.24	0.12	0.00	0.00	0.00	-2.44	5.97	0.00	-14.58	0.00
0.25	0.36	0.00	0.00	0.00	-2.20	4.82	0.00	-10.59	0.00
0.25	0.62	0.00	0.00	0.00	-1.94	3.78	0.00	-7.35	0.00
0.25	0.87	0.54	0.54	0.47	-1.69	2.86	55	-4.84	-2.61
0.25	1.12	0.99	1.53	1.11	-1.44	2.08	2.06	-3.00	-2.97
0.38	1.50	14.02	15.55	21.00	-1.06	1.13	15.82	-1.20	-16.80
0.38	1.88	9.95	25.50	18.71	-0.68	0.46	4.59	-0.31	-3.12
0.24	2.12	18.36	43.86	38.90	-0.44	0.19	3.57	-0.09	-1.58
0.25	2.37	13.49	57.35	31.94	-0.19	0.04	0.50	-0.01	-0.10
0.25	2.62	6.46	63.81	16.94	0.06	0.00	0.03	0.00	0.00
0.25	2.87	9.49	73.30	27.27	0.31	0.10	0.93	0.03	0.29
0.25	3.13	6.33	79.63	19.79	0.57	0.32	2.03	0.18	1.15
0.25	3.38	5.12	84.75	17.30	0.82	0.67	3.43	0.55	2.81
0.24	3.62	5.60	90.35	20.28	1.06	1.13	6.31	1.20	6.70
0.25	3.87	2.04	92.39	7.89	1.31	1.71	3.49	2.24	4.57
0.25	4.12	2.76	95.15	11.37	1.56	2.43	6.71	3.79	10.46
0.24	4.36	0.91	96.06	3.96	1.80	3.23	2.93	5.79	5.27
0.24	4.60	1.21	97.27	5.56	2.04	4.14	5.02	8.44	10.21
0.26	4.86	2.73	100.00	13.26	2.30	5.29	14.43	12.15	33.17
	sum	100.00		255.70			73.39		47.45
		2.24		2.56			0.86		0.75
		Mode		Mean			StandDev		Skewness



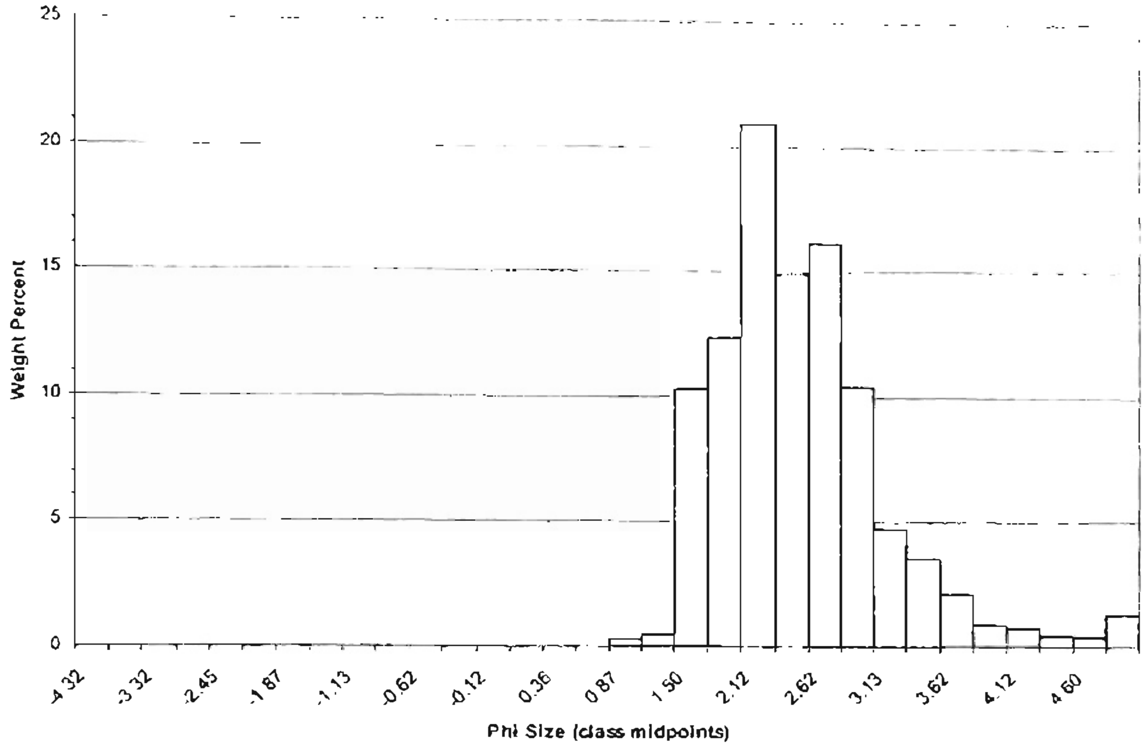
18
16
14
12
10
8
6
4
2
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



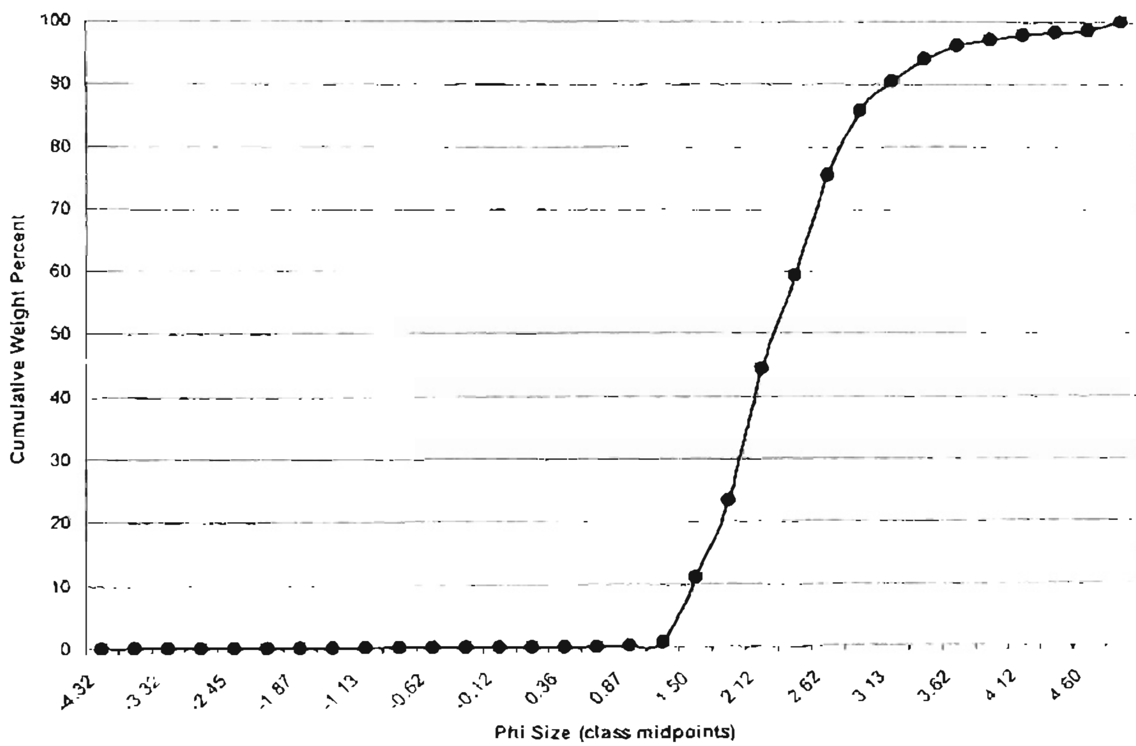
100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Alameda Street, 1.9 miles east of bridge

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.74	45.45	0.00	-306.44	0.00
0.50	-3.82	0.00	0.00	0.00	-6.24	38.06	0.00	-243.20	0.00
0.50	-3.32	0.00	0.00	0.00	-5.74	32.97	0.00	-189.31	0.00
0.49	-2.83	0.00	0.00	0.00	-5.25	27.54	0.00	-144.51	0.00
0.38	-2.45	0.00	0.00	0.00	-4.87	23.73	0.00	-115.62	0.00
0.33	-2.12	0.00	0.00	0.00	-4.54	20.65	0.00	-93.82	0.00
0.25	-1.87	0.00	0.00	0.00	-4.29	18.44	0.00	-79.10	0.00
0.37	-1.50	0.00	0.00	0.00	-3.92	15.36	0.00	-60.22	0.00
0.37	-1.13	0.00	0.00	0.00	-3.55	12.57	0.00	-44.57	0.00
0.25	-0.87	0.00	0.00	0.00	-3.29	10.85	0.00	-35.75	0.00
0.25	-0.62	0.00	0.00	0.00	-3.04	9.25	0.00	-28.15	0.00
0.25	-0.37	0.00	0.00	0.00	-2.79	7.77	0.00	-21.65	0.00
0.25	-0.12	0.00	0.00	0.00	-2.54	6.45	0.00	-16.38	0.00
0.24	0.12	0.00	0.00	0.00	-2.30	5.30	0.00	-12.21	0.00
0.25	0.36	0.00	0.00	0.00	-2.06	4.23	0.00	-8.69	0.00
0.25	0.62	0.00	0.00	0.00	-1.80	3.26	0.00	-5.88	0.00
0.25	0.87	0.29	0.29	0.25	-1.55	2.41	0.70	-3.73	1.08
0.25	1.12	0.48	0.77	0.54	-1.30	1.70	0.81	-2.21	-1.06
0.38	1.50	10.30	11.07	15.43	-0.92	0.85	8.76	-0.78	-8.08
0.38	1.88	12.36	23.43	23.24	-0.54	0.29	3.60	-0.16	-1.94
0.24	2.12	20.92	44.35	44.33	-0.30	0.09	1.90	-0.03	-0.57
0.25	2.37	14.90	59.26	35.29	-0.05	0.00	0.04	0.00	0.00
0.25	2.62	16.12	75.37	42.27	0.20	0.04	0.66	0.01	0.13
0.25	2.87	10.43	85.80	29.97	0.45	0.21	2.14	0.09	0.97
0.25	3.13	4.70	90.50	14.69	0.71	0.50	2.34	0.35	1.65
0.25	3.38	3.54	94.04	11.96	0.96	0.92	3.26	0.88	3.12
0.21	3.62	2.12	96.16	7.68	1.20	1.44	3.06	1.74	3.68
0.25	3.87	0.90	97.06	3.48	1.45	2.10	1.89	3.04	2.74
0.25	4.12	0.74	97.80	3.05	1.70	2.89	2.14	4.90	3.63
0.24	4.36	0.45	98.25	1.96	1.94	3.75	1.69	7.26	3.26
0.24	4.60	0.42	98.67	1.93	2.18	4.73	1.99	10.30	4.33
0.26	4.86	1.32	99.99	6.41	2.44	5.95	7.86	14.51	19.15
	sum	99.99		242.48			42.82		29.93
		2.24		2.42			0.65		1.07
		Mode		Mean			StandDev		Skewness



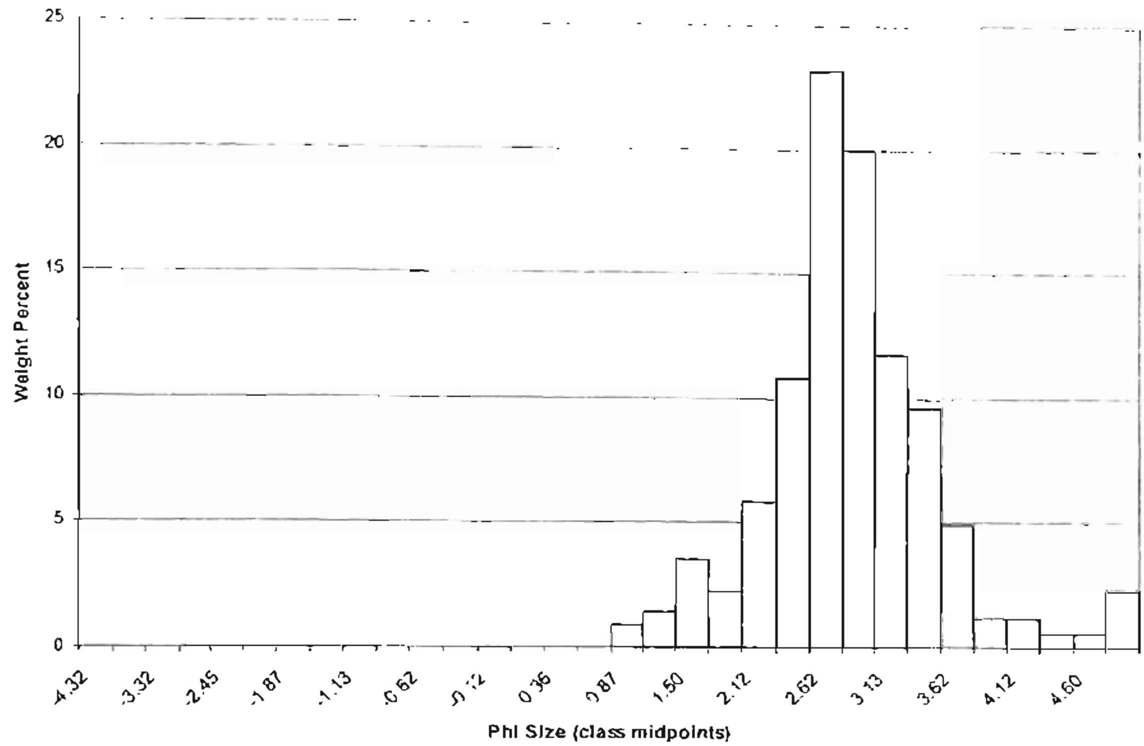
25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



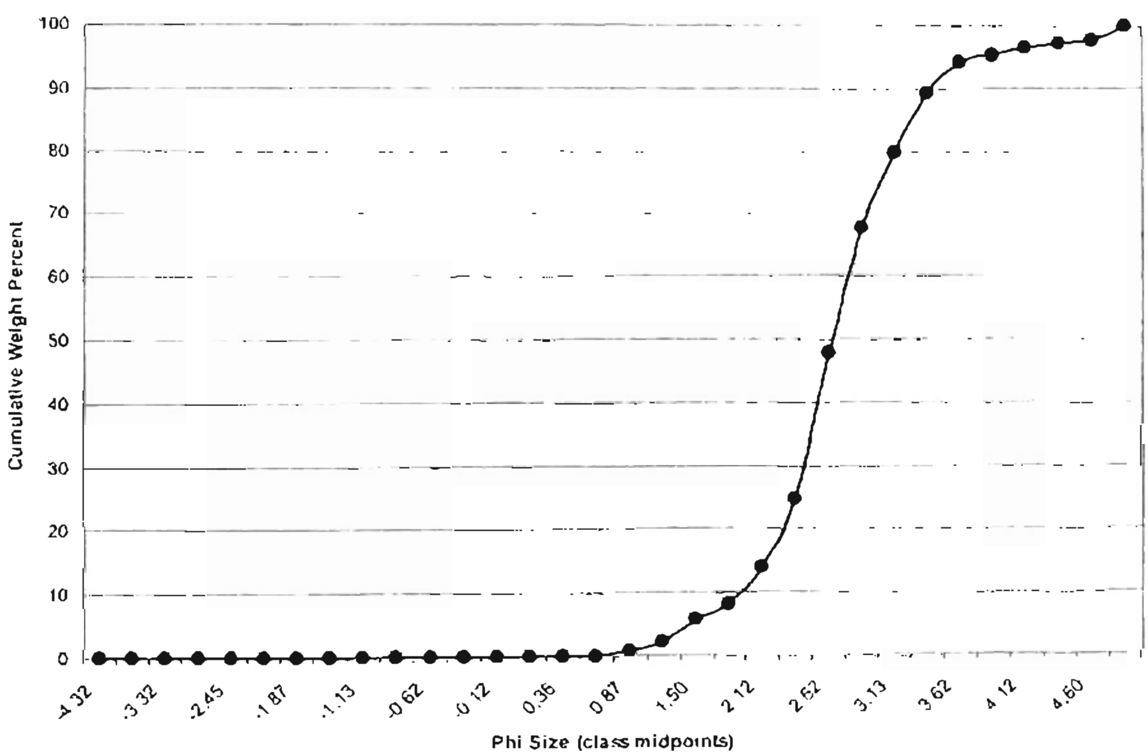
100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Alameda Street, 2.3 miles east of bridge near 120th Avenue

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	4.32	0.00	0.00	0.00	7.13	60.86	0.00	362.76	0.00
0.50	-3.82	0.00	0.00	0.00	-6.63	43.98	0.00	-291.69	0.00
0.50	-3.32	0.00	0.00	0.00	-6.13	37.60	0.00	-230.56	0.00
0.49	-2.83	0.00	0.00	0.00	-5.64	31.78	0.00	-179.18	0.00
0.38	-2.45	0.00	0.00	0.00	-5.26	27.68	0.00	-145.67	0.00
0.33	-2.12	0.00	0.00	0.00	-4.93	24.34	0.00	-120.11	0.00
0.25	-1.87	0.00	0.00	0.00	-4.68	21.94	0.00	-102.78	0.00
0.37	-1.50	0.00	0.00	0.00	-4.31	18.57	0.00	-80.05	0.00
0.37	-1.13	0.00	0.00	0.00	-3.94	15.49	0.00	-60.95	0.00
0.25	-0.87	0.00	0.00	0.00	-3.68	13.57	0.00	-50.01	0.00
0.25	-0.62	0.00	0.00	0.00	-3.43	11.78	0.00	-40.43	0.00
0.25	0.37	0.00	0.00	0.00	3.18	10.00	0.00	32.07	0.00
0.25	-0.12	0.00	0.00	0.00	-2.93	8.58	0.00	-25.14	0.00
0.24	0.12	0.00	0.00	0.00	-2.69	7.25	0.00	-19.53	0.00
0.25	0.36	0.00	0.00	0.00	-2.45	5.98	0.00	-14.63	0.00
0.25	0.62	0.00	0.00	0.00	-2.19	4.82	0.00	-10.57	0.00
0.25	0.87	0.87	0.87	0.76	-1.94	3.77	3.28	-7.32	-6.37
0.25	1.12	1.40	2.27	1.56	-1.69	2.87	4.01	-4.85	-6.79
0.38	1.50	3.57	5.34	5.35	-1.31	1.72	6.15	-2.26	-8.07
0.38	1.88	2.27	8.11	4.27	-0.93	0.86	1.96	-0.80	-1.82
0.24	2.12	5.85	13.38	12.40	-0.69	0.48	2.79	-0.33	-1.93
0.25	2.37	10.82	24.76	25.62	-0.44	0.20	2.11	-0.09	-0.93
0.25	2.62	23.14	47.32	60.68	0.19	0.04	0.81	0.01	0.15
0.25	2.87	19.95	67.37	57.32	0.06	0.00	0.08	0.00	0.01
0.25	3.13	11.74	79.31	36.70	0.32	0.10	1.17	0.03	0.37
0.25	3.38	9.61	89.22	32.47	0.57	0.32	3.11	0.18	1.77
0.24	3.62	4.88	94.10	17.67	0.81	0.66	3.21	0.53	2.61
0.25	3.87	1.21	95.31	4.68	1.06	1.12	1.36	1.19	1.43
0.25	4.12	1.21	96.52	4.98	1.31	1.71	2.07	2.24	2.71
0.24	4.36	0.58	97.10	2.53	1.55	2.39	1.39	3.69	2.14
0.24	4.60	0.58	97.68	2.67	1.79	3.19	1.85	5.70	3.30
0.26	4.86	2.32	100.00	11.27	2.05	4.20	9.74	8.60	19.96
	sum	100.00		280.93			45.10		8.24
		2.75		2.81			0.67		0.27
		Mode		Mean			StandDev		Skewness



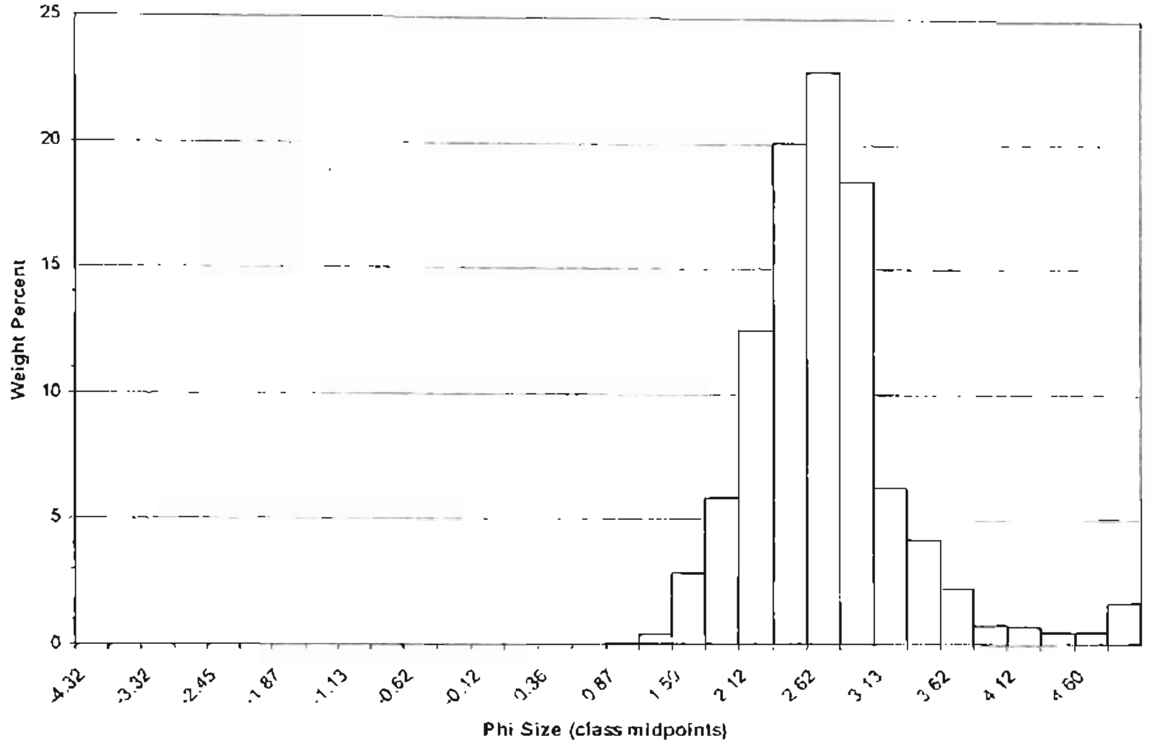
25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



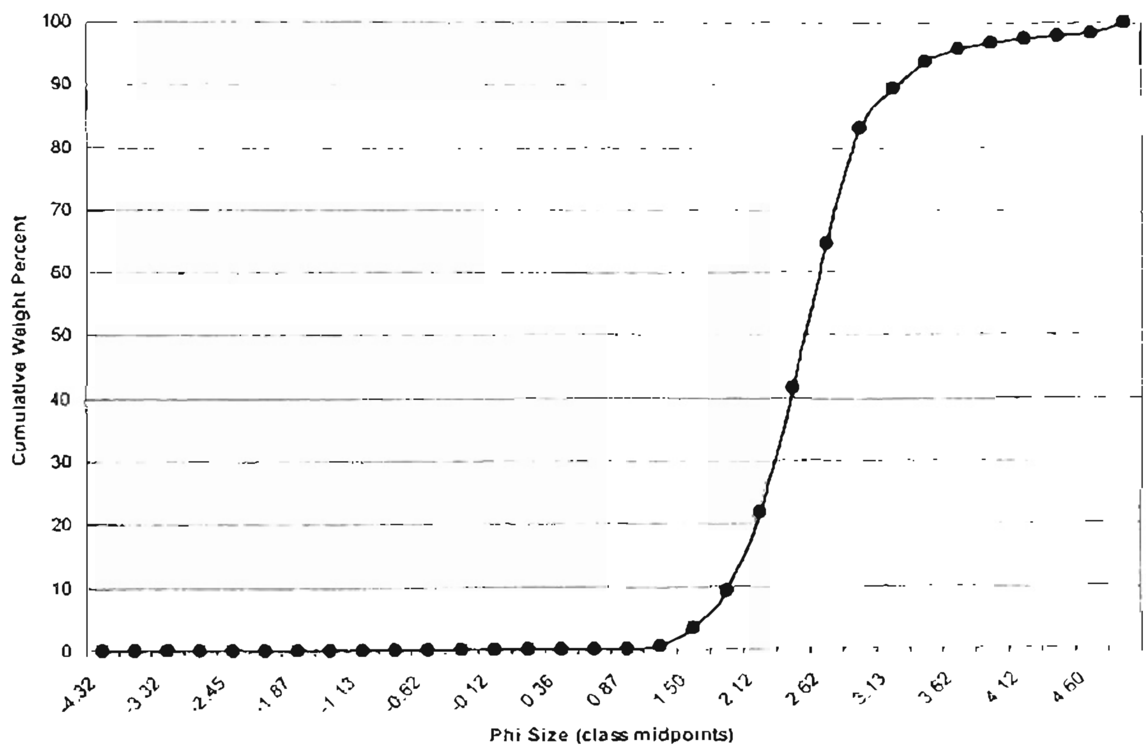
100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Alameda Street, 2.8 miles east of bridge across from the Central Oklahoma Master Conservancy District Reservoir Pumping Plant

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.95	48.33	0.00	-335.98	0.00
0.50	-3.82	0.00	0.00	0.00	-6.45	41.63	0.00	-268.58	0.00
0.50	-3.32	0.00	0.00	0.00	-5.95	35.43	0.00	-210.85	0.00
0.49	-2.83	0.00	0.00	0.00	-5.46	29.78	0.00	-162.66	0.00
0.38	-2.45	0.00	0.00	0.00	-5.08	25.82	0.00	-131.22	0.00
0.33	-2.12	0.00	0.00	0.00	-4.75	22.60	0.00	-107.44	0.00
0.25	-1.87	0.00	0.00	0.00	-4.50	20.29	0.00	-91.38	0.00
0.37	-1.50	0.00	0.00	0.00	-4.13	17.06	0.00	-70.43	0.00
0.37	-1.13	0.00	0.00	0.00	-3.76	14.10	0.00	-52.97	0.00
0.25	-0.87	0.00	0.00	0.00	-3.50	12.28	0.00	-43.03	0.00
0.25	-0.62	0.00	0.00	0.00	-3.25	10.58	0.00	-34.39	0.00
0.25	-0.37	0.00	0.00	0.00	-3.00	9.00	0.00	-26.93	0.00
0.25	-0.12	0.00	0.00	0.00	-2.75	7.56	0.00	-20.78	0.00
0.24	0.12	0.00	0.00	0.00	-2.51	6.31	0.00	-15.87	0.00
0.25	0.36	0.00	0.00	0.00	-2.27	5.13	0.00	-11.63	0.00
0.25	0.62	0.00	0.00	0.00	-2.01	4.06	0.00	-8.12	0.00
0.25	0.87	0.06	0.06	0.05	-1.76	3.10	0.19	-5.47	-0.33
0.25	1.12	0.43	0.49	0.48	-1.51	2.29	0.98	-3.46	-1.49
0.38	1.50	2.81	3.30	4.21	-1.13	1.28	3.60	-1.45	-4.08
0.38	1.88	5.86	9.16	11.02	-0.75	0.56	3.29	-0.42	-2.47
0.24	2.12	12.52	21.68	26.53	-0.51	0.26	3.27	-0.13	-1.37
0.25	2.37	20.02	41.70	47.41	-0.26	0.07	1.37	-0.02	-0.36
0.25	2.62	22.89	64.59	60.03	-0.01	0.00	0.00	0.00	0.00
0.25	2.87	18.50	83.09	53.18	0.24	0.06	1.10	0.01	0.27
0.25	3.13	6.29	89.38	19.66	0.50	0.25	1.55	0.12	0.77
0.25	3.38	4.21	93.59	14.23	0.75	0.56	2.36	0.42	1.77
0.24	3.62	2.26	95.85	8.18	0.99	0.98	2.22	0.98	2.20
0.25	3.87	0.79	96.64	3.06	1.24	1.53	1.21	1.90	1.50
0.25	4.12	0.73	97.37	3.01	1.49	2.22	1.62	3.30	2.41
0.24	4.33	0.49	97.86	2.13	1.73	2.98	1.46	5.14	2.52
0.24	4.60	0.49	98.35	2.25	1.97	3.88	1.89	7.60	3.72
0.25	4.85	1.65	100.00	8.02	2.23	4.97	8.20	11.07	18.27
	sum	100.00		263.42			34.31		23.04
		2.75		2.63			0.59		1.15
		Mode		Mean			StandDev		Skewness



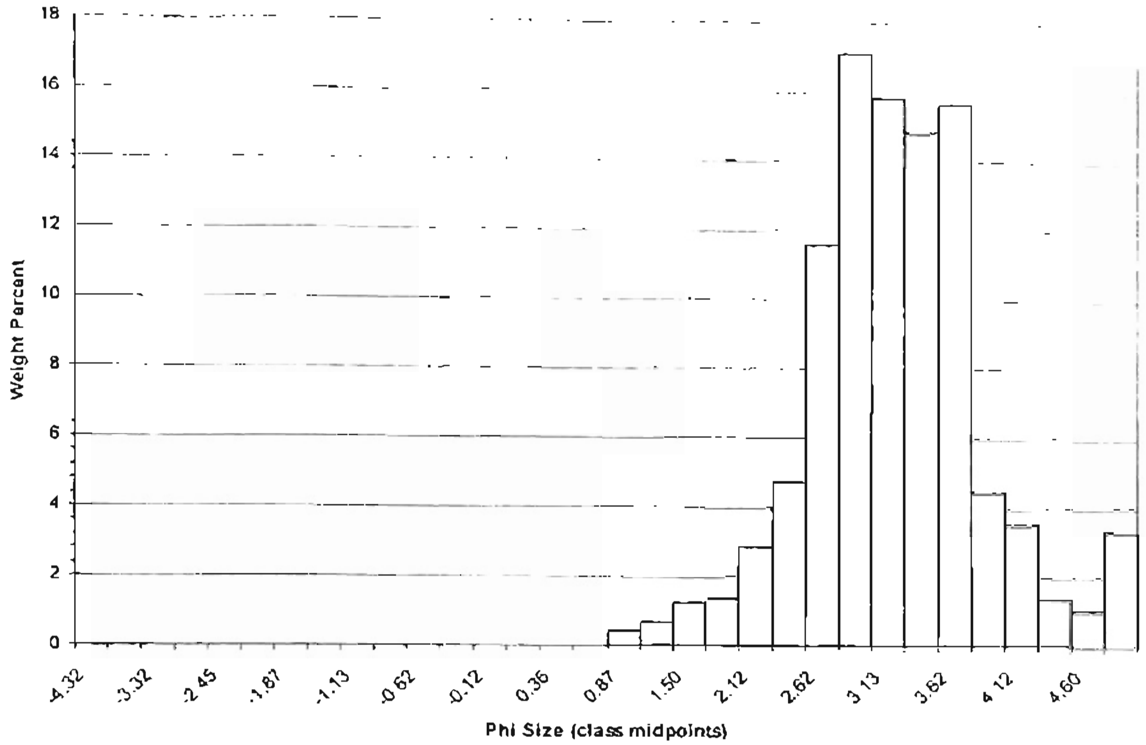
Weight Percent
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

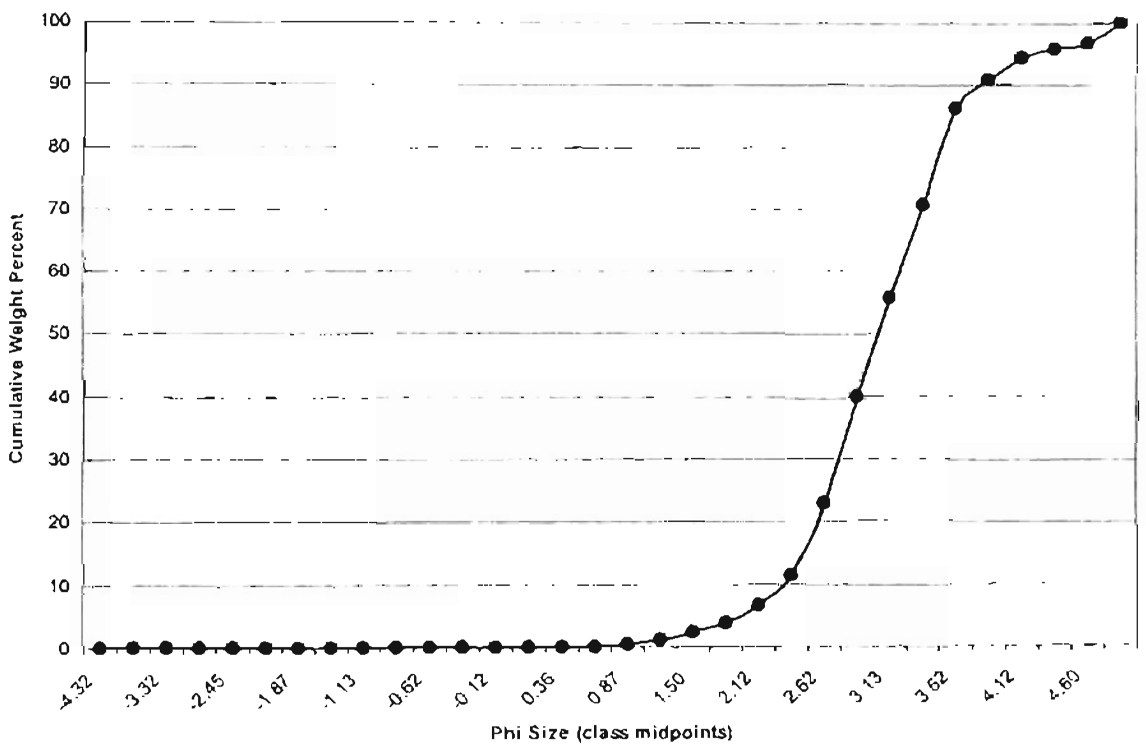


Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.49	56.13	0.00	-420.51	0.00
0.50	-3.82	0.00	0.00	0.60	-6.99	48.89	0.00	-341.81	0.00
0.50	-3.32	0.00	0.00	0.00	-6.49	42.15	0.00	-273.60	0.00
0.49	-2.83	0.00	0.00	0.00	-6.00	35.97	0.00	-215.75	0.00
0.38	-2.45	0.00	0.00	0.00	-5.62	31.60	0.00	-177.66	0.00
0.33	-2.12	0.00	0.00	0.00	-5.29	28.03	0.00	-148.37	0.00
0.25	-1.87	0.00	0.00	0.00	-5.04	25.44	0.00	-128.35	0.00
0.37	-1.50	0.00	0.00	0.00	-4.67	21.81	0.00	-101.83	0.00
0.37	-1.13	0.00	0.00	0.00	-4.30	18.45	0.00	-79.26	0.00
0.25	-0.87	0.00	0.00	0.00	-4.04	16.36	0.00	-66.15	0.00
0.25	-0.62	0.00	0.00	0.00	-3.79	14.38	0.00	-54.53	0.00
0.25	-0.37	0.00	0.00	0.00	-3.54	12.51	0.00	-44.26	0.00
0.25	-0.12	0.00	0.00	0.00	-3.29	10.82	0.00	-35.59	0.00
0.24	0.12	0.00	0.00	0.00	-3.05	9.32	0.00	-28.45	0.00
0.25	0.36	0.00	0.00	0.00	-2.81	7.87	0.00	-22.09	0.00
0.25	0.62	0.00	0.00	0.00	-2.55	6.53	0.00	-16.67	0.00
0.25	0.87	0.42	0.42	0.36	-2.30	5.30	2.22	-12.19	-5.12
0.25	1.12	0.66	1.08	0.74	-2.05	4.21	2.78	-8.65	-5.71
0.38	1.50	1.25	2.33	1.87	-1.67	2.80	3.50	-4.68	-5.84
0.38	1.88	1.37	3.70	2.58	-1.29	1.66	2.28	-2.14	-2.94
0.24	2.12	2.86	6.56	6.06	-1.05	1.10	3.16	-1.16	-3.32
0.25	2.37	4.71	11.27	11.15	-0.80	0.64	3.03	-0.52	-2.43
0.25	2.62	11.56	22.83	30.31	-0.55	0.30	3.47	-0.16	-1.9
0.25	2.87	17.10	39.93	49.13	-0.30	0.09	1.51	-0.03	-0.45
0.25	3.13	15.85	55.78	49.54	-0.04	0.00	0.03	0.00	0.00
0.25	3.38	14.84	70.62	50.14	0.21	0.04	0.65	0.01	0.14
0.24	3.62	15.67	86.29	56.75	0.45	0.20	3.20	0.09	1.44
0.25	3.87	4.47	90.76	17.29	0.70	0.49	2.18	0.34	1.52
0.25	4.12	3.52	94.28	14.50	0.95	0.90	3.17	0.85	3.01
0.24	4.36	1.37	95.65	5.97	1.19	1.41	1.93	1.67	2.28
0.24	4.60	1.01	96.66	4.54	1.43	2.03	2.05	2.90	2.93
0.26	4.86	3.34	100.00	16.23	1.69	2.85	9.53	4.82	16.09
	sum	100.00		317.28			44.67		-0.29
		3.00		3.17			0.67		-0.01
		Mode		Mean			StandDev		Skewness

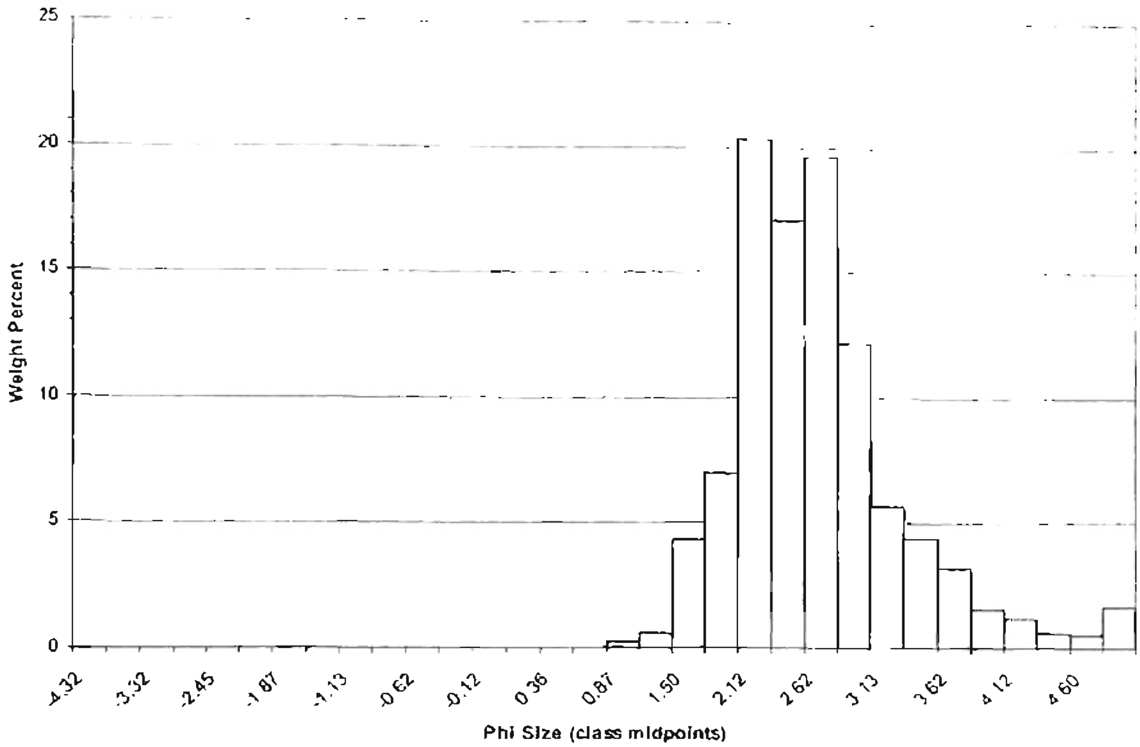
Alameda Street, 3.2 miles east of bridge


Weight Percent
18
16
14
12
10
8
6
4
2
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

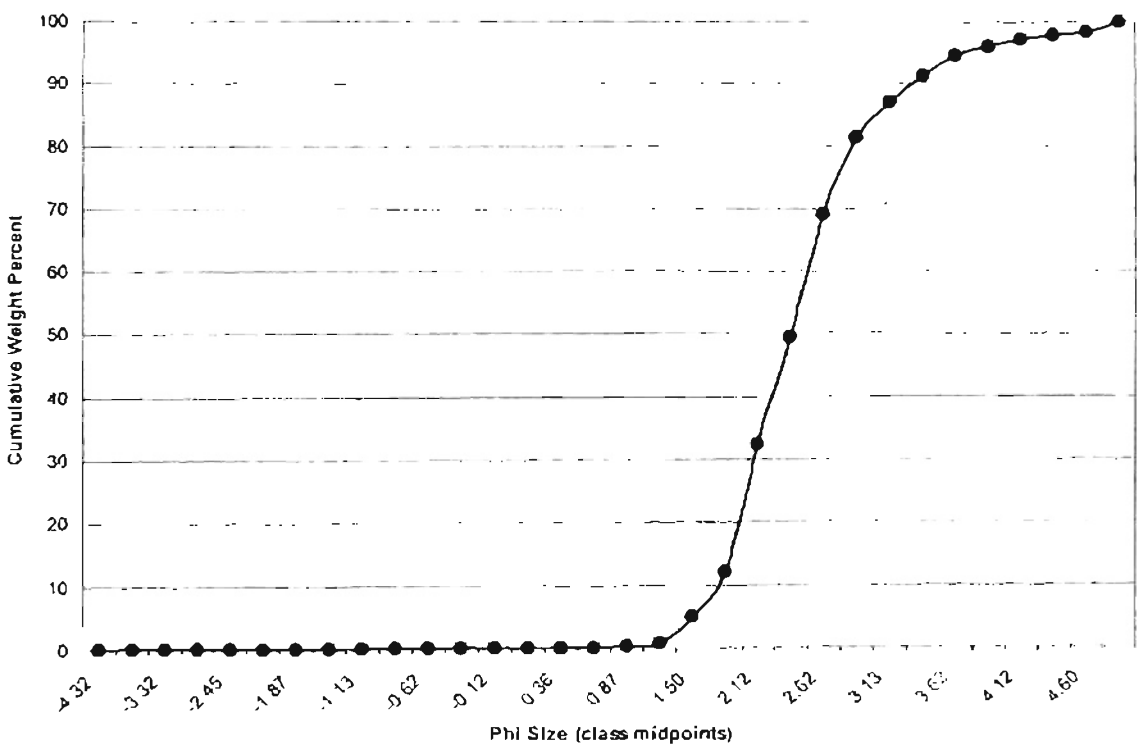

Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Alameda Street, 3.6 miles east of bridge near Indian Point Visitor Information Center

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
nterval	-4.32	0.00	0.00	0.00	-6.90	47.64	0.00	-328.78	0.00
0.50	-3.82	0.00	0.00	0.00	-0.40	40.98	0.00	-202.38	0.00
0.50	-3.32	0.00	0.00	0.00	-5.90	34.83	0.00	-205.58	0.00
0.49	-2.83	0.00	0.00	0.00	-5.41	29.24	0.00	-158.14	0.00
0.30	-2.45	0.00	0.00	0.00	-5.00	25.32	0.00	-127.39	0.00
0.33	-2.12	0.00	0.00	0.00	-4.70	22.13	0.00	-104.09	0.00
0.25	-1.87	0.00	0.00	0.00	-4.45	19.84	0.00	-88.37	0.00
0.37	-1.50	0.00	0.00	0.00	-4.08	16.64	0.00	-67.90	0.00
0.37	-1.13	0.00	0.00	0.00	-3.71	13.73	0.00	-50.88	0.00
0.25	-0.87	0.00	0.00	0.00	-3.45	11.93	0.00	-41.21	0.00
0.25	-0.62	0.00	0.00	0.00	-3.20	10.25	0.00	-32.83	0.00
0.25	-0.37	0.00	0.00	0.00	-2.95	8.69	0.00	-25.60	0.00
0.25	-0.12	0.00	0.00	0.00	-2.70	7.29	0.00	-19.67	0.00
0.24	0.12	0.00	0.00	0.00	-2.46	6.07	0.00	-14.94	0.00
0.25	0.36	0.00	0.00	0.00	-2.22	4.91	0.00	-10.88	0.00
0.25	0.32	0.00	0.00	0.00	-1.96	3.86	0.00	-7.58	0.00
0.25	0.37	0.21	0.21	0.18	-1.71	2.93	0.62	-5.01	-1.05
0.25	1.12	0.57	0.78	0.64	-1.46	2.14	1.22	-3.13	-1.78
0.38	1.50	4.29	5.07	6.43	-1.08	1.17	5.02	-1.27	-5.44
0.38	1.38	6.95	12.02	13.07	-0.70	0.49	3.40	-0.34	-2.38
0.24	2.12	20.32	32.34	43.06	-0.46	0.21	4.32	-0.10	-1.99
0.25	2.37	17.06	49.40	40.40	-0.21	0.04	0.77	-0.01	-0.16
0.25	2.32	19.65	69.05	51.53	0.04	0.00	0.04	0.00	0.00
0.25	2.37	12.20	81.25	35.05	0.29	0.09	1.05	0.03	0.31
0.25	3.13	5.67	86.92	17.72	0.55	0.30	1.69	0.16	0.92
0.25	3.38	4.40	91.32	14.87	0.80	0.64	2.81	0.51	2.24
0.24	3.32	3.19	94.51	11.55	1.04	1.09	3.46	1.13	3.61
0.25	3.37	1.52	96.03	5.88	1.29	1.66	2.52	2.14	3.25
0.25	4.12	1.21	97.24	4.98	1.54	2.37	2.87	3.64	4.41
0.24	4.38	0.57	97.81	2.48	1.78	3.15	1.80	5.60	3.19
0.24	4.30	0.53	98.34	2.44	2.02	4.06	2.15	8.19	4.34
0.26	4.36	1.67	100.01	8.11	2.28	5.19	8.67	11.84	19.77
	sum	**100.01**		**258.40**			**42.40**		**29.24**
		2.24		**2.58**			**0.65**		**1.06**
		Mode		*Mean*			*StandDev*		*Skewness*



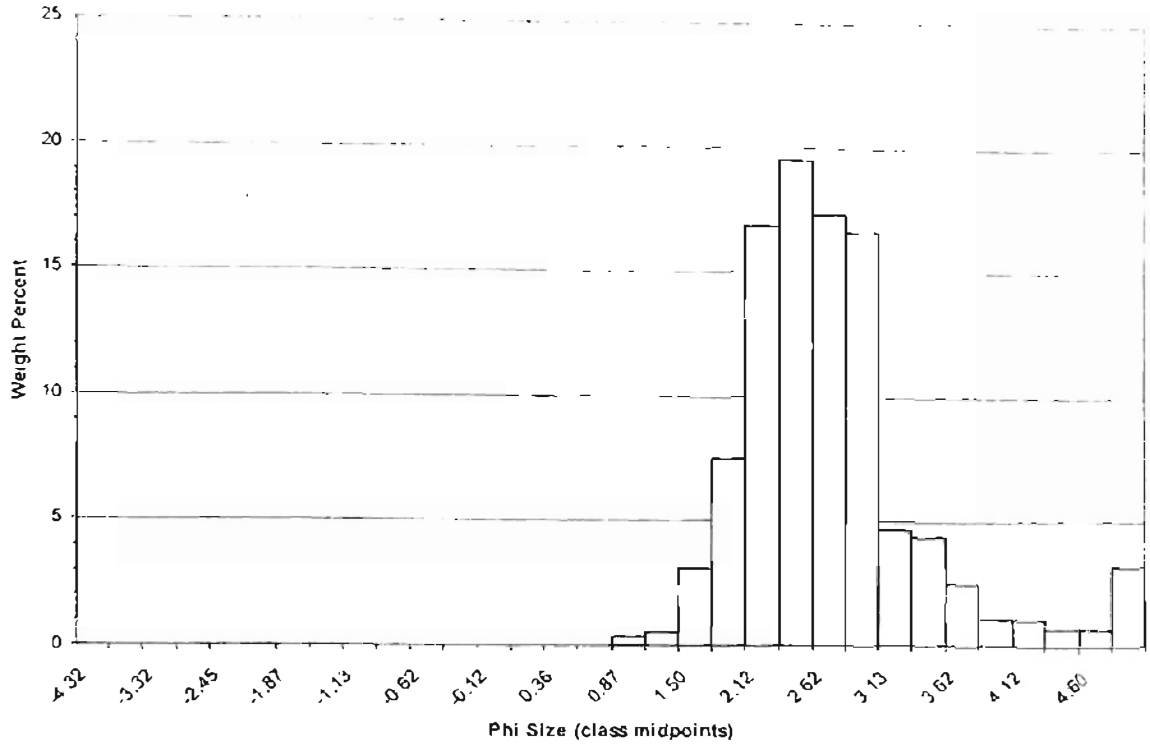
25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

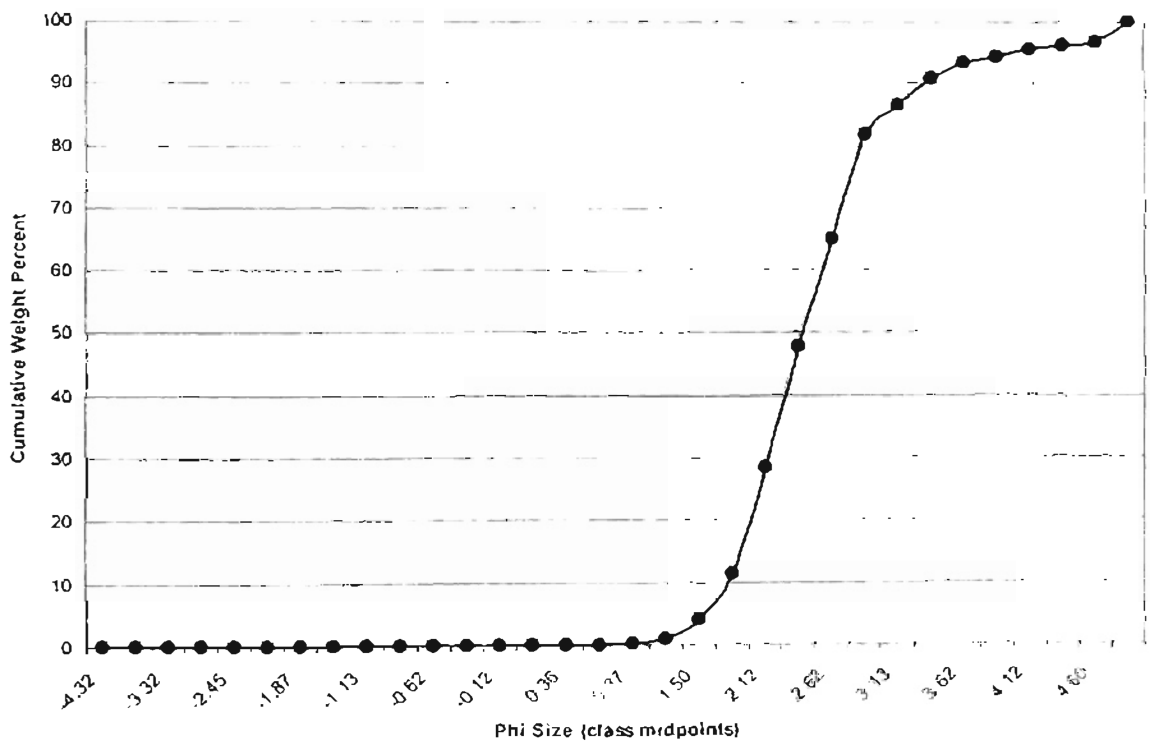


100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
4.12
4.60
Phi Size (class midpoints)

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.95	48.33	0.00	-335.98	0.00
0.50	-3.82	0.00	0.00	0.00	-6.45	41.63	0.00	-268.59	0.00
0.50	-3.32	0.00	0.00	0.00	-5.95	35.43	0.00	-210.85	0.00
0.49	-2.83	0.00	0.00	0.00	-5.46	29.79	0.00	-162.56	0.00
0.38	-2.45	0.00	0.00	0.00	-5.08	25.82	0.00	-131.22	0.00
0.33	-2.12	0.00	0.00	0.00	-4.75	22.60	0.00	-107.44	0.00
0.25	-1.87	0.00	0.00	0.00	-4.50	20.29	0.00	-91.38	0.00
0.37	-1.50	0.00	0.00	0.00	-4.13	17.05	0.00	-70.43	0.00
0.37	-1.13	0.00	0.00	0.00	-3.76	14.10	0.00	-52.97	0.00
0.25	-0.87	0.00	0.00	0.00	-3.50	12.28	0.00	-43.03	0.00
0.25	-0.62	0.00	0.00	0.00	-3.25	10.58	0.00	-34.39	0.00
0.25	-0.37	0.00	0.00	0.00	-3.00	8.98	0.00	-26.93	0.00
0.25	-0.12	0.00	0.00	0.00	-2.75	7.56	0.00	-20.78	0.00
0.24	0.12	0.00	0.00	0.00	-2.51	6.31	0.00	-15.87	0.00
0.25	0.36	0.00	0.00	0.00	-2.27	5.13	0.00	-11.63	0.00
0.25	0.62	0.00	0.00	0.00	-2.01	4.06	0.00	-8.17	0.00
0.25	0.87	0.33	0.33	0.29	-1.76	3.10	1.02	-5.47	-1.80
0.25	1.12	0.52	0.85	0.58	-1.51	2.29	1.19	-3.46	-1.80
0.38	1.50	3.08	3.93	4.61	-1.13	1.28	3.95	-1.45	-4.47
0.39	1.88	7.53	11.46	14.15	-0.75	0.56	4.23	-0.42	-3.17
0.24	2.12	16.82	28.28	35.64	-0.51	0.26	4.33	-0.13	-2.25
0.25	2.37	19.52	47.80	46.22	-0.26	0.07	1.34	-0.02	-0.35
0.25	2.62	17.29	65.09	45.31	-0.01	0.00	0.00	0.00	0.00
0.25	2.87	16.63	81.72	47.73	0.24	0.06	0.93	0.01	0.24
0.25	3.13	4.69	86.41	14.65	0.50	0.25	1.15	0.12	0.57
0.25	3.38	4.36	90.77	14.73	0.75	0.56	2.45	0.42	1.83
0.24	3.62	2.51	93.28	9.09	0.99	0.98	2.47	0.98	2.45
0.25	3.87	1.04	94.32	4.02	1.24	1.53	1.63	1.90	1.98
0.25	4.12	1.09	95.41	4.49	1.49	2.22	2.42	3.30	3.60
0.24	4.36	0.71	96.12	3.09	1.73	2.98	2.11	5.14	3.65
0.24	4.60	0.66	96.78	3.03	1.97	3.86	2.55	7.60	5.01
0.26	4.86	3.22	100.00	15.65	2.23	4.97	16.00	11.07	35.66
	sum	100.00		263.40			47.85		41.15
		2.50		2.63			0.69		1.24
		Mode		Mean			StandDev		Skewness

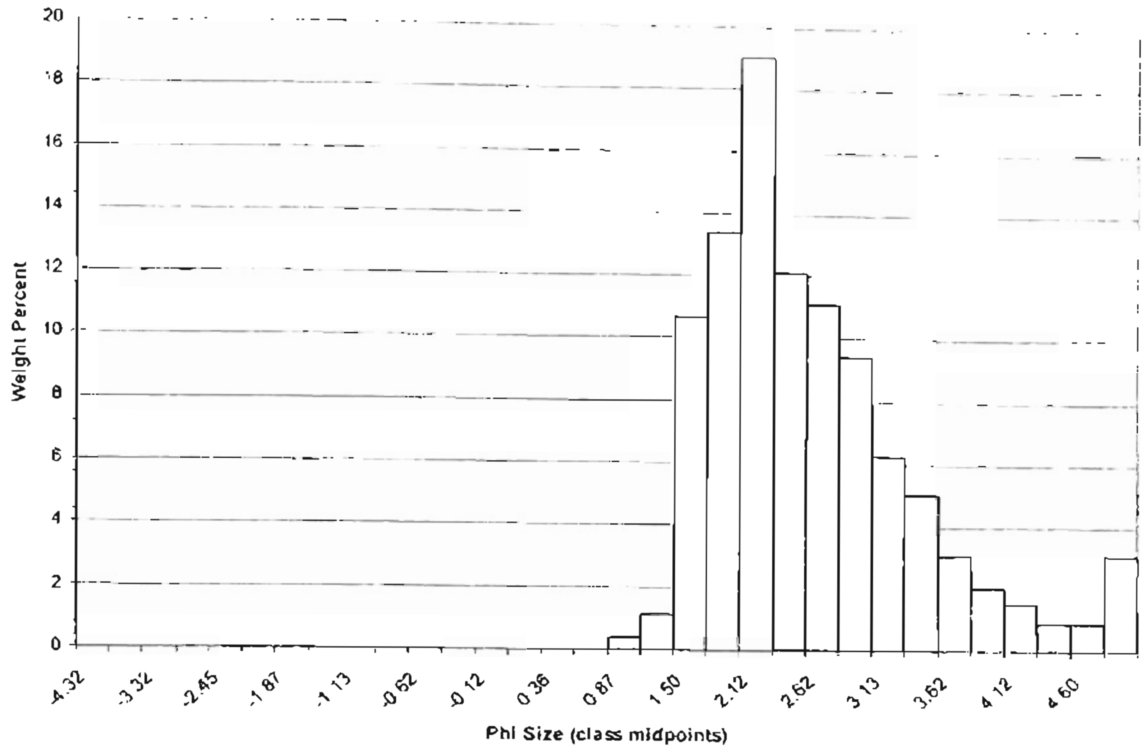
Alameda Street, 3.9 miles east of bridge



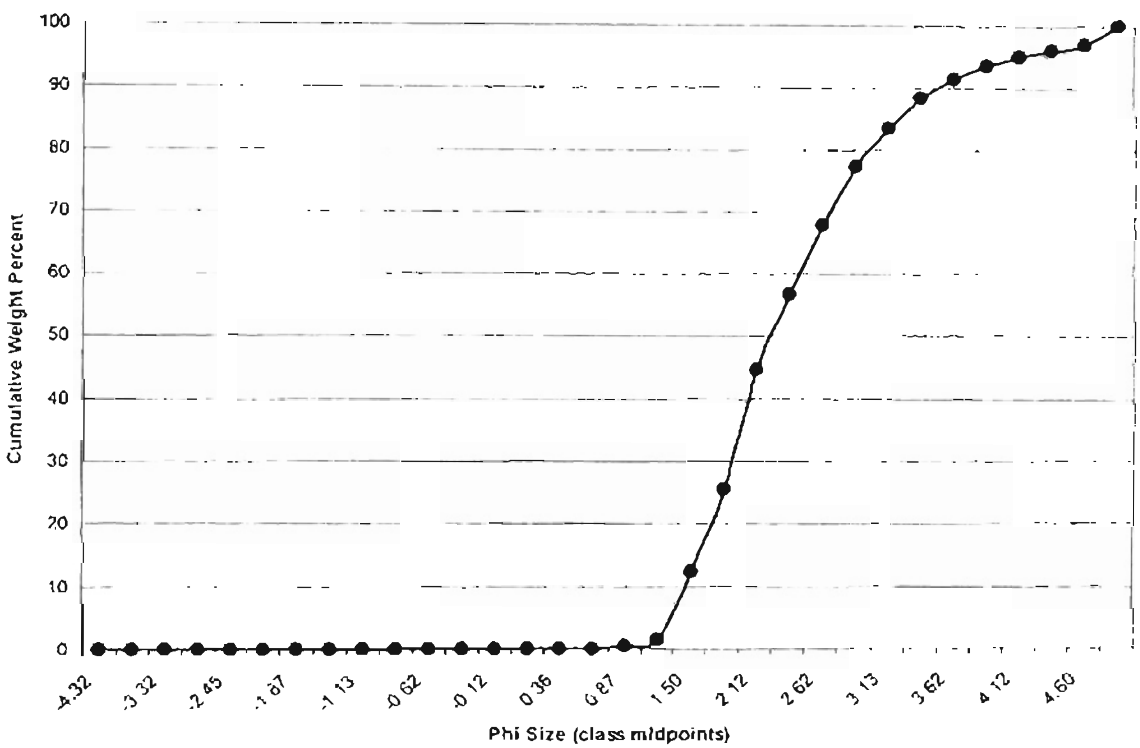


Alameda Street at the Marina

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
nterva.	-4.32	0.00	0.00	0.00	-6.85	46.95	0.00	-321.69	0.00
0.50	-3.82	0.00	0.00	0.00	-6.35	40.35	0.00	-256.28	0.00
0.50	-3.32	0.00	0.00	0.00	-5.85	34.25	0.00	-200.40	0.00
0.49	-2.83	0.00	0.00	0.00	-5.36	28.70	0.00	-153.79	0.00
0.38	-2.45	0.00	0.00	0.00	-4.98	24.82	0.00	-123.63	0.00
0.33	-2.12	0.00	0.00	0.00	-4.65	21.66	0.00	-100.80	0.00
0.25	-1.87	0.00	0.00	0.00	-4.40	19.40	0.00	-85.43	0.00
0.37	-1.50	0.00	0.00	0.00	-4.03	16.24	0.00	-65.44	0.00
0.37	-1.13	0.00	0.00	0.00	-3.66	13.36	0.00	-48.85	0.00
0.25	-0.87	0.00	0.00	0.00	-3.40	11.59	0.00	-39.45	0.00
0.25	-0.62	0.00	0.00	0.00	-3.15	9.94	0.00	-31.32	0.00
0.25	-0.37	0.00	0.00	0.00	-2.90	8.39	0.00	-24.32	0.00
0.25	-0.12	0.00	0.00	0.00	-2.65	7.02	0.00	-18.60	0.00
0.24	0.12	0.00	0.00	0.00	-2.41	5.82	0.00	-14.05	0.00
0.25	0.36	0.00	0.00	0.00	-2.17	4.69	0.00	-10.16	0.00
0.25	0.62	0.00	0.00	0.00	-1.91	3.67	0.00	-7.02	0.00
0.25	0.67	0.40	0.40	0.35	-1.66	2.76	1.10	-4.59	-1.83
0.25	1.12	1.13	1.53	1.26	-1.41	2.00	2.26	-2.82	-3.19
0.38	1.50	10.69	12.22	16.01	-1.03	1.07	11.38	-1.10	-11.75
0.38	1.88	13.38	25.60	25.16	-0.65	0.42	5.64	-0.27	-3.66
0.24	2.12	19.03	44.63	40.32	-0.41	0.17	3.22	-0.07	-1.32
0.25	2.37	12.09	56.72	28.63	-0.16	0.03	0.32	0.00	-0.05
0.25	2.62	11.13	67.85	29.19	0.09	0.01	0.10	0.00	0.01
0.25	2.37	9.40	77.25	27.01	0.34	0.12	1.11	0.04	0.38
0.25	3.12	6.24	93.49	13.50	0.60	0.35	2.21	0.21	1.32
0.25	3.38	5.01	88.50	16.93	0.85	0.72	3.61	0.61	3.07
0.24	3.62	3.09	91.59	11.19	1.09	1.19	3.68	1.30	4.02
0.25	3.87	2.03	93.62	7.85	1.34	1.79	3.64	2.40	4.87
0.25	4.12	1.49	95.11	6.14	1.59	2.52	3.76	4.01	5.98
0.24	4.36	0.90	96.01	3.92	1.83	3.33	3.00	6.09	5.48
0.24	4.60	0.90	96.91	4.14	2.07	4.27	3.84	8.82	7.94
0.26	4.86	3.09	100.00	15.01	2.33	5.42	16.76	12.63	39.03
	sum	100.00		252.62			65.63		50.27
		2.24 Mode		2.53 Mean			0.81 StandDev		0.95 Skewness



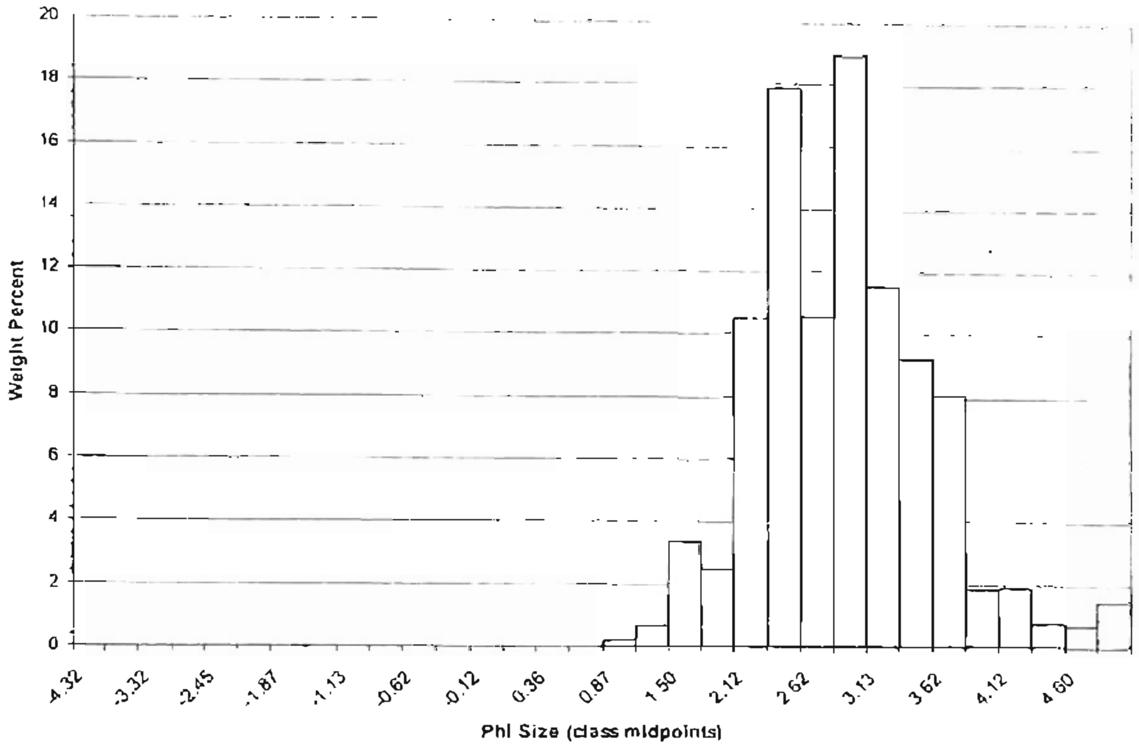
Weight Percent
0
2
4
6
8
10
12
14
16
18
20
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



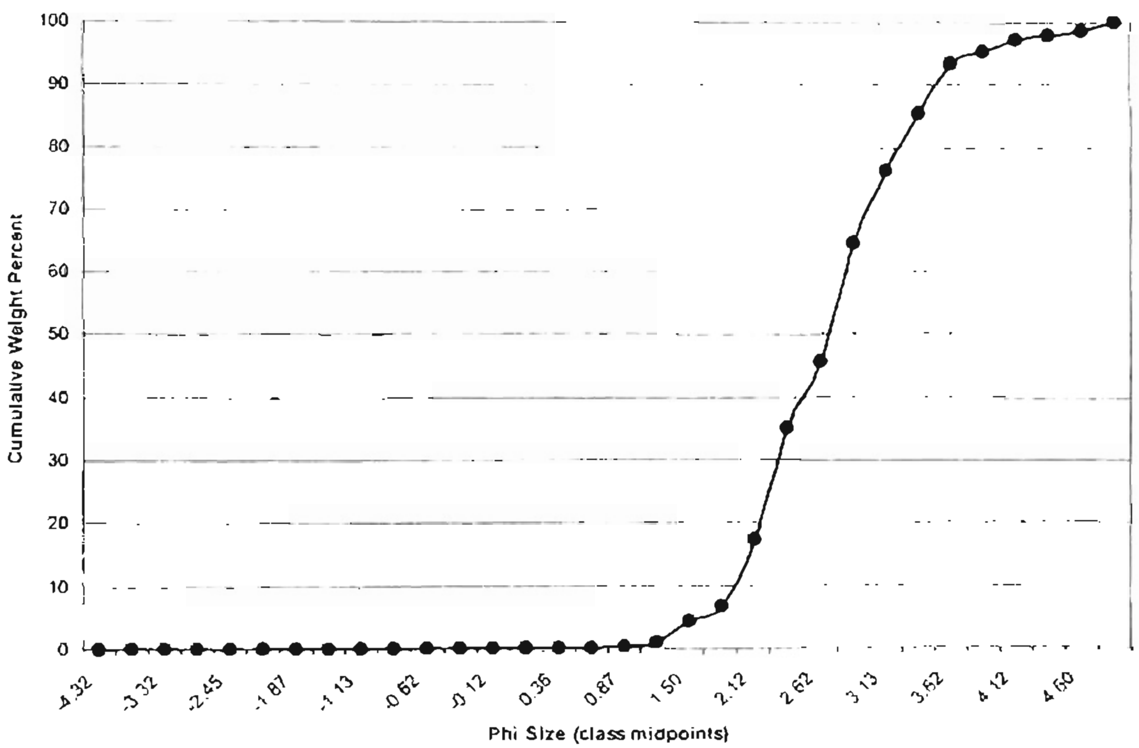
Cumulative Weight Percent
0
10
20
30
40
50
60
70
80
90
100
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interva	-4.32	0.00	0.00	0.00	-7.14	51.01	0.00	-364.29	0.00
0.50	-3.82	0.00	0.00	0.00	-6.64	44.12	0.00	-293.01	0.00
0.50	-3.32	0.00	0.00	0.00	-6.14	37.72	0.00	-231.69	0.00
0.49	-2.83	0.00	0.00	0.00	-5.65	31.93	0.00	-180.14	0.00
0.30	-2.45	0.00	0.00	0.00	-5.27	27.79	0.00	-146.50	0.00
0.33	-2.12	0.00	0.00	0.00	-4.94	24.44	0.00	-120.84	0.00
0.25	-1.87	0.00	0.00	0.00	-4.69	22.04	0.00	-103.44	0.00
0.37	-1.50	0.00	0.00	0.00	-4.32	18.65	0.00	-80.61	0.00
0.37	-1.13	0.00	0.00	0.00	-3.95	15.57	0.00	-61.42	0.00
0.25	-0.87	0.00	0.00	0.00	-3.69	13.65	0.00	-50.42	0.00
0.25	-0.62	0.00	0.00	0.00	-3.44	11.85	0.00	-40.78	0.00
0.25	-0.37	0.00	0.00	0.00	-3.19	10.16	0.00	-32.38	0.00
0.25	-0.12	0.00	0.00	0.00	-2.94	8.64	0.00	-25.40	0.00
0.24	0.12	0.00	0.00	0.00	-2.70	7.30	0.00	-19.74	0.00
0.25	0.36	0.00	0.00	0.00	-2.46	6.03	0.00	-14.81	0.00
0.25	0.62	0.00	0.00	0.00	-2.20	4.85	0.00	-10.71	0.00
0.25	0.97	0.19	0.19	0.17	-1.95	3.81	0.72	-7.43	-1.41
0.25	1.12	0.68	0.87	0.76	-1.70	2.89	1.97	-4.94	-3.36
0.39	1.50	3.38	4.25	5.06	-1.32	1.75	5.91	-2.31	-7.81
0.38	1.98	2.46	6.71	4.63	-0.94	0.88	2.17	-0.83	-2.04
0.24	2.12	10.48	17.19	22.21	-0.70	0.49	5.15	-0.34	-3.61
0.25	2.37	17.87	35.06	42.32	-0.45	0.20	3.65	-0.09	-1.65
0.25	2.62	10.53	45.59	27.61	-0.20	0.04	0.41	-0.01	-0.08
0.25	2.87	18.94	64.53	54.42	0.05	0.00	0.05	0.00	0.00
0.25	3.13	11.55	76.08	36.10	0.31	0.03	1.08	0.03	0.33
0.25	3.38	9.23	85.31	31.19	0.56	0.31	2.88	0.17	1.61
0.24	3.62	8.02	93.33	29.05	0.80	0.64	5.15	0.52	4.13
0.25	3.87	1.84	95.17	7.12	1.05	1.10	2.02	1.15	2.12
0.25	4.12	1.88	97.05	7.74	1.30	1.69	3.17	2.19	4.12
0.24	4.36	0.77	97.82	3.35	1.54	2.35	1.82	3.62	2.79
0.24	4.60	0.72	98.54	3.31	1.78	3.15	2.27	5.60	4.03
0.26	4.86	1.45	99.99	7.05	2.04	4.16	6.03	8.48	12.29
	sum	99.99		282.08			44.47		11.47
		3.00		2.82			0.67		0.39
		Mode		Mean			StandDev		Skewness

Rock Creek Road, 1.1 miles east of Pebbly Road



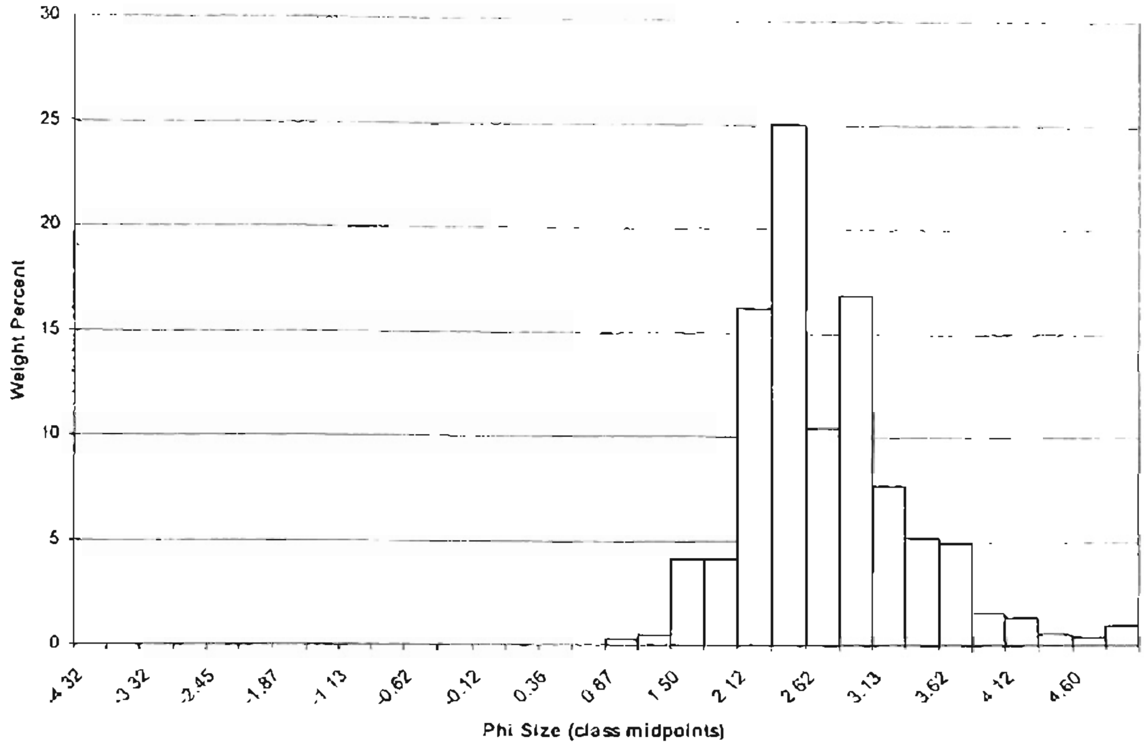
Weight Percent
20
18
16
14
12
10
8
6
4
2
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



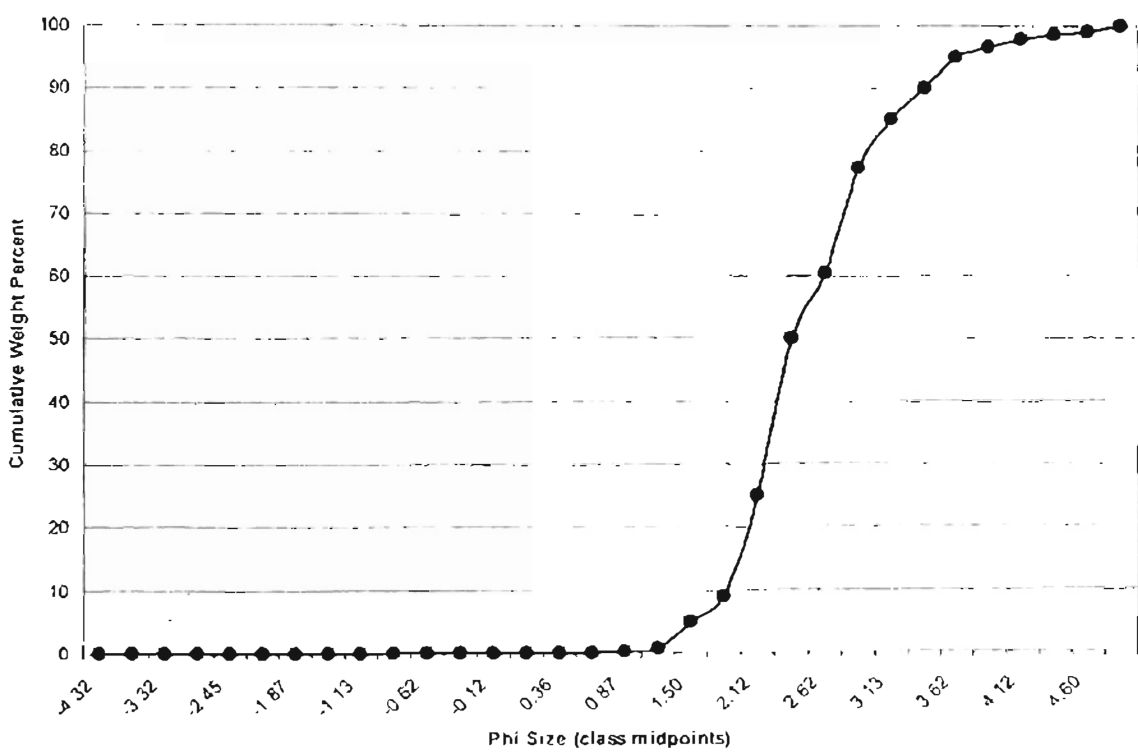
Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.96	48.47	0.00	-337.43	0.00
0.50	-3.82	0.00	0.00	0.00	-6.46	41.76	0.00	-269.83	0.00
0.50	-3.32	0.00	0.00	0.00	-5.96	35.54	0.00	-211.91	0.00
0.49	-2.83	0.00	0.00	0.00	-5.47	29.90	0.00	-163.46	0.00
0.38	-2.45	0.00	0.00	0.00	-5.09	25.92	0.00	-132.00	0.00
0.33	-2.12	0.00	0.00	0.00	-4.76	22.70	0.00	-108.12	0.00
0.25	-1.87	0.00	0.00	0.00	-4.51	20.38	0.00	-91.99	0.00
0.37	-1.50	0.00	0.00	0.00	-4.14	17.14	0.00	-70.94	0.00
0.37	-1.13	0.00	0.00	0.00	-3.77	14.18	0.00	-53.39	0.00
0.25	-0.87	0.00	0.00	0.00	-3.51	12.35	0.00	-43.40	0.00
0.25	-0.62	0.00	0.00	0.00	-3.26	10.64	0.00	-34.71	0.00
0.25	-0.37	0.00	0.00	0.00	-3.01	9.04	0.00	-27.20	0.00
0.25	-0.12	0.00	0.00	0.00	-2.76	7.61	0.00	-21.01	0.00
0.24	0.12	0.00	0.00	0.00	-2.52	6.36	0.00	-16.06	0.00
0.25	0.33	0.00	0.00	0.00	-2.28	5.18	0.00	-11.79	0.00
0.25	0.62	0.00	0.00	0.00	-2.02	4.10	0.00	-8.30	0.00
0.25	0.87	0.28	0.28	0.24	-1.77	3.14	0.88	-5.56	-1.56
0.25	1.12	0.50	0.78	0.56	-1.52	2.32	1.16	-3.53	-1.77
0.38	1.50	4.10	4.88	0.14	-1.14	1.30	5.35	-1.49	-6.11
0.38	1.83	4.08	8.96	7.67	-0.76	0.58	2.35	-0.44	-1.79
0.24	2.12	16.15	25.11	34.22	-0.52	0.27	4.38	-0.14	-2.28
0.25	2.37	25.07	50.18	59.37	-0.27	0.07	1.85	-0.02	-0.50
0.25	2.62	10.41	60.59	27.30	-0.02	0.00	0.00	0.00	0.00
0.25	2.87	16.79	77.38	48.24	0.23	0.05	0.91	0.01	0.21
0.25	3.13	7.03	85.01	23.85	0.49	0.24	1.80	0.11	0.87
0.25	3.33	5.17	90.18	17.42	0.74	0.55	2.82	0.40	2.09
0.24	3.62	4.89	95.07	17.71	0.98	0.96	4.71	0.95	4.63
0.25	3.87	1.50	96.53	6.03	1.23	1.51	2.35	1.86	2.89
0.25	4.12	1.36	97.99	5.60	1.48	2.19	2.97	3.23	4.40
0.24	4.33	0.55	98.54	2.40	1.72	2.94	1.62	5.05	2.78
0.24	4.60	0.40	99.00	2.1[illegible]	1.96	3.83	1.70	7.48	3.44
0.26	4.85	1.01	100.01	4.9	2.22	4.92	4.97	10.93	11.03
	sum	100.01		263.83			39.91		18.34
		2.50		2.64			0.83		0.73
		Mode		*Mean*			*StandDev*		*Skewness*

Rock Creek Road, 1.5 miles east of Pebbly Road



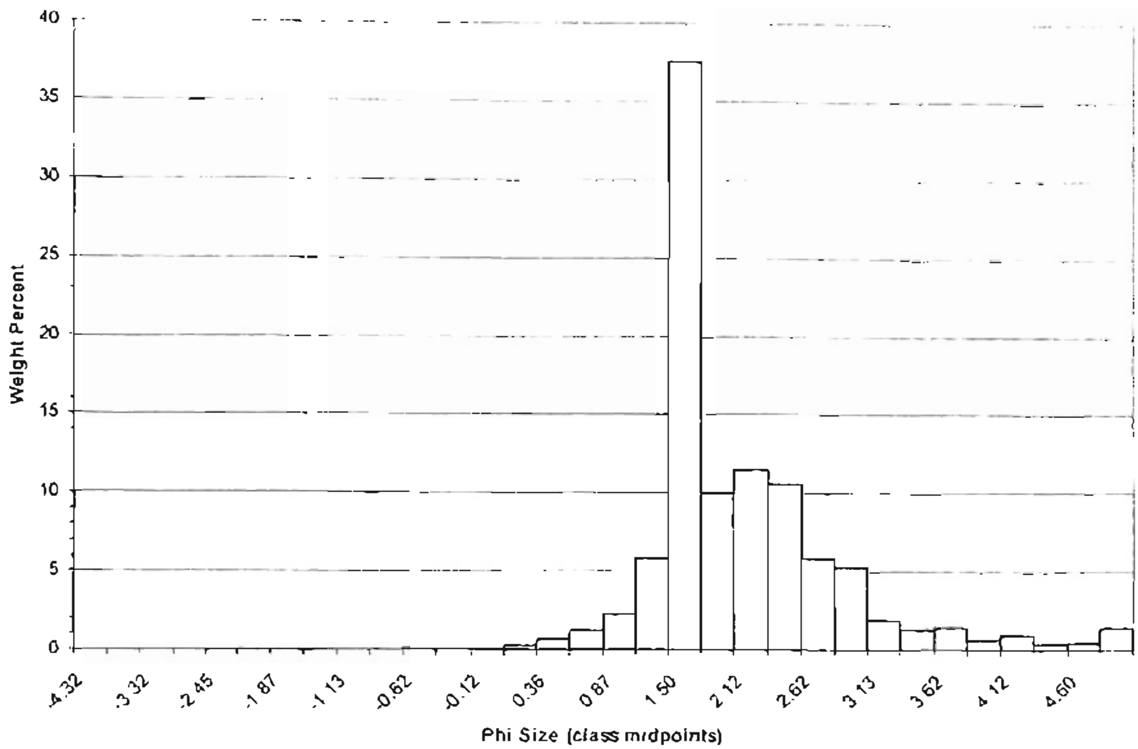
Weight Percent
30
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



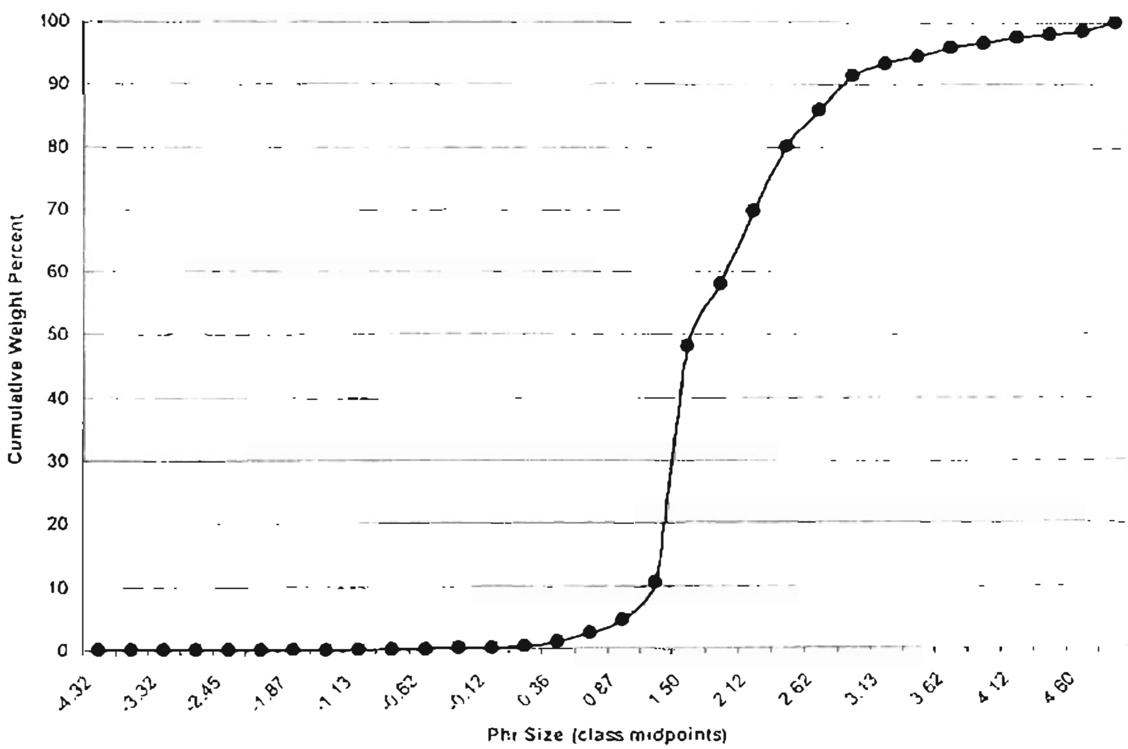
Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Rock Creek Road, 1.8 miles east of Pebbly Road

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	4.32	0.00	0.00	0.00	6.29	39.50	0.00	249.00	0.00
0.50	-3.82	0.00	0.00	0.00	-5.79	33.55	0.00	-194.30	0.00
0.50	-3.32	0.00	0.00	0.00	-5.29	28.00	0.00	-148.20	0.00
0.49	-2.83	0.00	0.00	0.00	-4.80	23.02	0.00	-110.43	0.00
0.38	-2.45	0.00	0.00	0.00	-4.42	19.55	0.00	-86.45	0.00
0.33	-2.12	0.00	0.00	0.00	-4.09	16.76	0.00	-68.62	0.00
0.25	-1.87	0.00	0.00	0.00	-3.84	14.78	0.00	-56.81	0.00
0.37	-1.50	0.00	0.00	0.00	-3.47	12.04	0.00	-41.77	0.00
0.37	-1.13	0.00	0.00	0.00	-3.10	9.58	0.00	-29.66	0.00
0.25	-0.87	0.00	0.00	0.00	-2.84	8.09	0.00	-23.01	0.00
0.25	-0.62	0.06	0.06	-0.04	-2.59	6.72	0.40	-17.42	-1.04
0.25	-0.37	0.13	0.19	-0.05	-2.34	5.46	0.71	-12.77	-1.66
0.25	-0.12	0.13	0.32	-0.02	-2.09	4.37	0.57	-9.12	-1.19
0.24	0.12	0.26	0.58	0.03	-1.85	3.43	0.89	-6.36	-1.65
0.25	0.35	0.70	1.28	0.26	-1.61	2.58	1.80	-4.14	-2.90
0.25	0.62	1.22	2.50	0.75	-1.35	1.83	2.24	-2.48	-3.03
0.25	0.87	2.24	4.74	1.95	-1.10	1.21	2.72	-1.34	-2.99
0.25	1.12	5.83	10.57	6.51	-0.85	0.73	4.24	-0.62	-3.62
0.38	1.50	37.54	48.11	56.23	-0.47	0.22	8.37	-0.11	-3.95
0.38	1.83	9.99	58.10	18.73	-0.09	0.01	0.08	0.00	-0.01
0.24	2.12	11.53	69.63	24.43	0.15	0.02	0.26	0.00	0.04
0.25	2.37	10.63	80.26	25.17	0.40	0.16	1.68	0.06	0.67
0.25	2.62	5.89	86.15	15.45	0.65	0.43	2.51	0.28	1.64
0.25	2.87	5.32	91.47	15.29	0.90	0.82	4.34	0.74	3.92
0.25	3.13	1.92	93.39	6.00	1.16	1.34	2.56	1.54	2.96
0.25	3.38	1.28	94.67	4.33	1.41	1.99	2.54	2.80	3.58
0.24	3.62	1.41	96.08	5.11	1.65	2.73	3.85	4.51	6.35
0.25	3.87	0.70	96.78	2.71	1.90	3.60	2.52	6.84	4.79
0.25	4.12	0.90	97.68	3.71	2.15	4.62	4.16	9.92	8.93
0.24	4.36	0.38	98.06	1.66	2.39	5.69	2.16	13.58	5.16
0.24	4.60	0.51	98.57	2.34	2.63	6.90	3.52	18.11	9.23
0.26	4.86	1.41	99.98	6.85	2.89	8.35	11.77	24.11	34.00
	sum	99.90		197.44			63.09		59.23
		1.76		1.97			0.80		1.16
		Mode		Mean			StandDev		Skewness



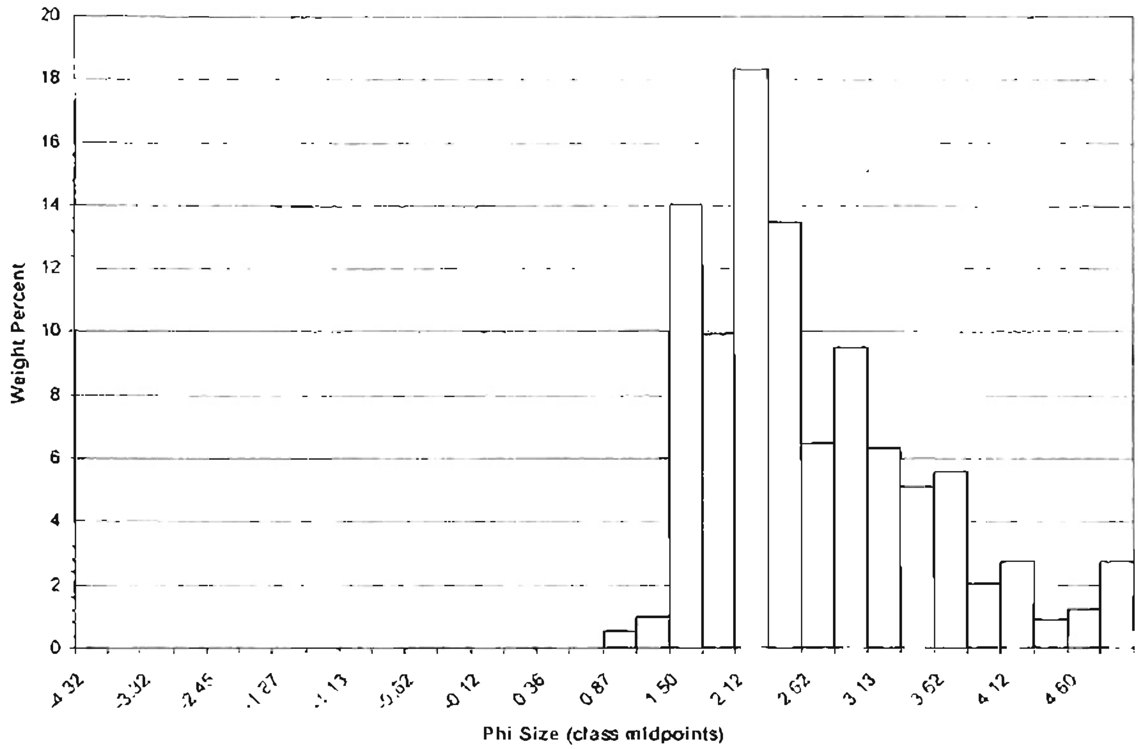
Weight Percent
0
5
10
15
20
25
30
35
40
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



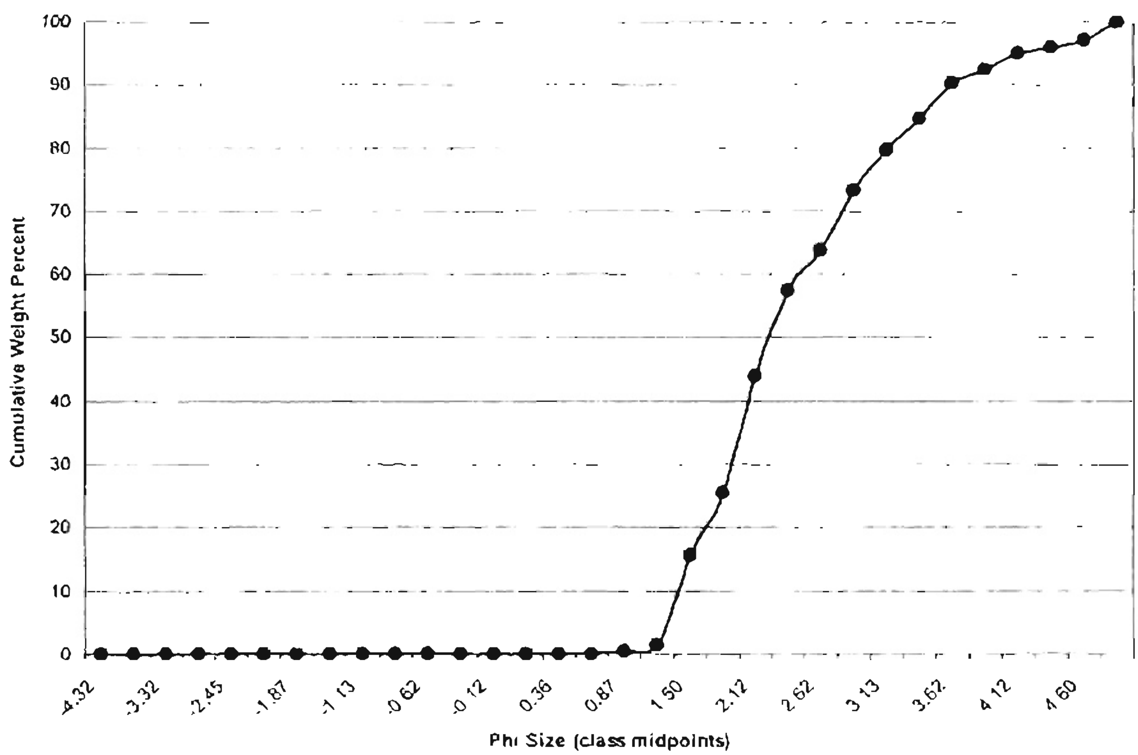
Cumulative Weight Percent
0
10
20
30
40
50
60
70
80
90
100
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Rock Creek Road, 2.6 miles east of Pebbly Road

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.88	47.36	0.00	-325.93	0.00
0.50	-3.82	0.00	0.00	0.00	-6.38	40.73	0.00	-259.93	0.00
0.50	-3.32	0.00	0.00	0.00	-5.88	34.60	0.00	-203.50	0.00
0.49	-2.83	0.00	0.00	0.00	-5.39	29.03	0.00	-156.39	0.00
0.38	-2.45	0.00	0.00	0.00	-5.01	25.12	0.00	-125.88	0.00
0.33	-2.12	0.00	0.00	0.00	-4.68	21.94	0.00	-102.76	0.00
0.25	-1.87	0.00	0.00	0.00	-4.43	19.66	0.00	-87.19	0.00
0.37	-1.50	0.00	0.00	0.00	-4.06	16.48	0.00	-66.91	0.00
0.37	-1.13	0.00	0.00	0.00	-3.69	13.58	0.00	-50.06	0.00
0.25	-0.87	0.00	0.00	0.00	-3.43	11.79	0.00	-40.50	0.00
0.25	-0.62	0.00	0.00	0.00	-3.18	10.13	0.00	-32.22	0.00
0.25	-0.37	0.00	0.00	0.00	-2.93	8.57	0.00	-25.08	0.00
0.25	-0.12	0.00	0.00	0.00	-2.60	7.10	0.00	-19.24	0.00
0.24	0.12	0.00	0.00	0.00	-2.44	5.97	0.00	-14.58	0.00
0.25	0.36	0.00	0.00	0.00	-2.20	4.82	0.00	-10.59	0.00
0.25	0.62	0.00	0.00	0.00	-1.94	3.78	0.00	-7.35	0.00
0.25	0.87	0.54	0.54	0.47	-1.69	2.86	1.55	-4.84	-2.61
0.25	1.12	0.99	1.53	1.11	-1.44	2.08	2.06	-3.00	-2.97
0.38	1.50	14.02	15.55	21.00	-1.06	1.13	15.82	-1.20	-16.80
0.38	1.88	9.95	25.50	18.71	-0.68	0.46	4.59	-0.31	-3.12
0.24	2.12	18.36	43.86	38.90	-0.44	0.19	3.57	-0.09	-1.58
0.25	2.37	13.49	57.35	31.94	-0.19	0.04	0.50	-0.01	-0.10
0.25	2.62	6.48	63.84	16.94	0.06	0.00	0.03	0.00	0.00
0.25	2.87	9.49	73.30	27.27	0.31	0.10	0.93	0.03	0.29
0.25	3.13	6.33	79.63	19.79	0.57	0.32	2.03	0.18	1.15
0.25	3.38	5.12	84.75	17.30	0.82	0.67	3.43	0.55	2.81
0.24	3.62	5.60	90.35	20.28	1.06	1.13	6.31	1.20	6.70
0.25	3.87	2.04	92.39	7.89	1.31	1.71	3.49	2.24	4.57
0.25	4.12	2.76	95.15	11.37	1.56	2.43	6.71	3.79	10.46
0.24	4.36	0.91	96.06	3.96	1.80	3.23	2.93	5.79	5.27
0.24	4.60	1.21	97.27	5.56	2.04	4.14	5.02	8.44	10.21
0.26	4.86	2.73	100.00	13.26	2.30	5.29	14.43	12.15	33.17
	sum	100.00		255.70			73.39		47.45
		2.24		2.56			0.86		0.75
		Mode		***Mean***			***StandDev***		***Skewness***



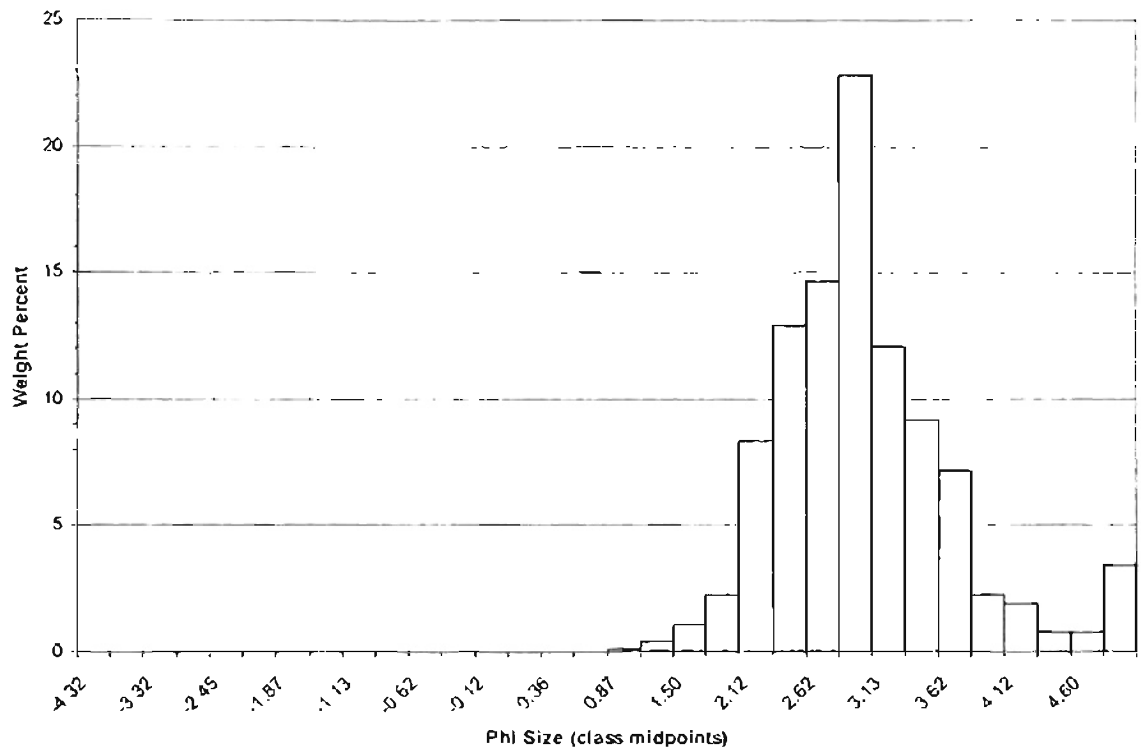
Weight Percent
Phi Size (class midpoints)



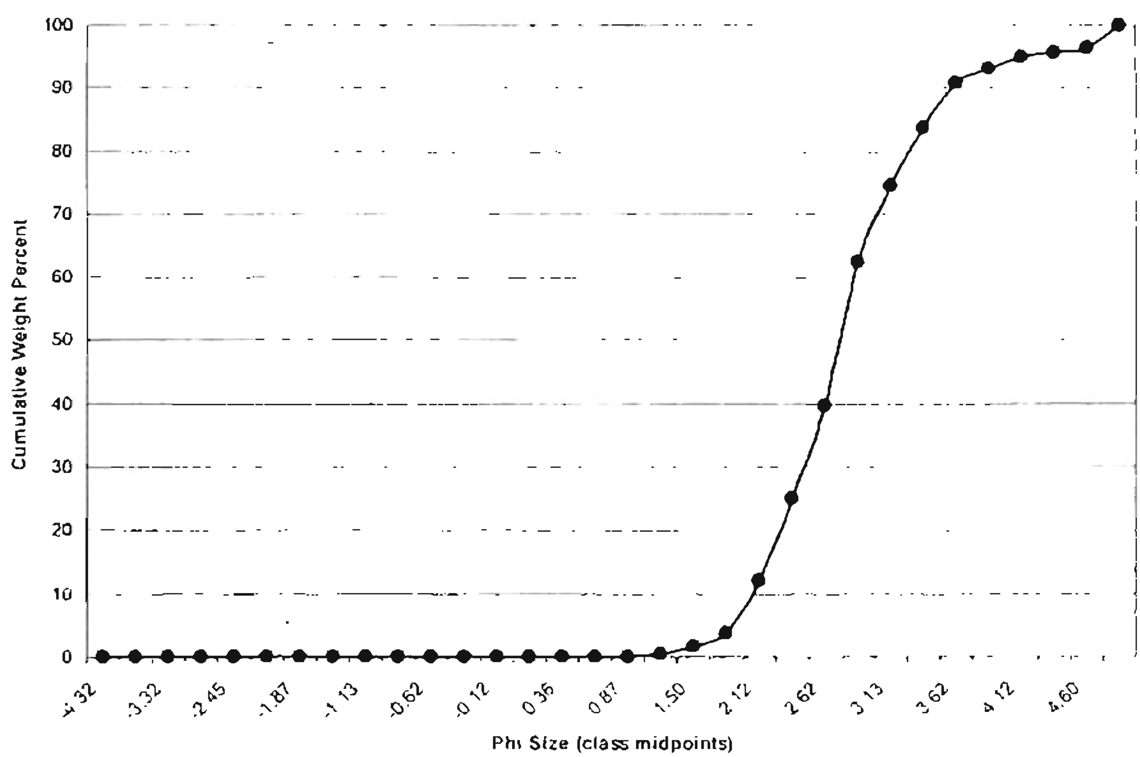
Cumulative Weight Percent
Phi Size (class midpoints)

Franklin Street at Pebbly Intersection

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	4.32	0.00	0.00	0.00	7.25	52.50	0.00	381.38	0.00
0.50	-3.82	0.00	0.00	0.00	-6.75	45.59	0.00	-307.81	0.00
0.50	-3.32	0.00	0.00	0.00	-6.25	39.09	0.00	-244.37	0.00
0.49	-2.83	0.00	0.00	0.00	-5.76	33.15	0.00	-190.87	0.00
0.38	-2.45	0.00	0.00	0.00	-5.38	28.96	0.00	-155.86	0.00
0.33	-2.12	0.00	0.00	0.00	-5.05	25.54	0.00	-129.09	0.00
0.25	-1.87	0.00	0.00	0.00	-4.80	23.08	0.00	-110.88	0.00
0.37	-1.53	0.00	0.00	0.00	-4.43	19.62	0.00	-86.92	0.00
0.37	-1.13	0.00	0.00	0.00	-4.06	16.45	0.00	-66.70	0.00
0.25	-0.87	0.00	0.00	0.00	-3.80	14.47	0.00	-55.06	0.00
0.25	-0.82	0.00	0.00	0.00	-3.55	12.62	0.00	-44.82	0.00
0.25	-0.37	0.00	0.00	0.00	-3.30	10.87	0.00	-35.85	0.00
0.25	-0.12	0.00	0.00	0.00	-3.05	9.30	0.00	-28.36	0.00
0.24	0.12	0.00	0.00	0.00	-2.81	7.91	0.00	-22.25	0.00
0.25	0.36	0.00	0.00	0.00	-2.57	6.58	0.00	-16.89	0.00
0.25	0.62	0.00	0.00	0.00	-2.31	5.36	0.00	-12.40	0.00
0.25	0.87	0.10	0.10	0.09	-2.06	4.25	0.42	-8.75	-0.88
0.25	1.12	0.43	0.53	0.48	-1.81	3.29	1.40	-5.96	-2.54
0.38	1.53	1.09	1.61	1.53	-1.43	2.05	2.23	-2.94	-3.19
0.38	1.83	2.24	3.85	4.21	-1.05	1.10	2.46	-1.16	-2.58
0.24	2.12	6.32	12.17	17.63	-0.81	0.66	5.47	-0.53	-4.44
0.25	2.37	12.89	25.06	30.52	-0.56	0.32	4.07	-0.18	-2.29
0.25	2.62	14.63	39.69	38.37	-0.31	0.09	1.38	-0.03	-0.43
0.25	2.87	22.79	62.40	65.40	-0.06	0.00	0.07	0.00	0.00
0.25	3.13	12.07	74.55	37.72	0.20	0.04	0.46	0.01	0.09
0.25	3.33	9.14	83.69	30.89	0.45	0.20	1.84	0.09	0.83
0.24	3.62	7.14	90.83	25.84	0.69	0.48	3.41	0.33	2.36
0.25	3.87	2.24	93.06	8.65	0.94	0.88	1.97	0.83	1.85
0.25	4.12	1.91	94.97	7.85	1.19	1.41	2.70	1.68	3.20
0.24	4.33	0.79	95.76	3.44	1.43	2.03	1.60	2.90	2.29
0.24	4.60	0.79	96.55	3.63	1.67	2.78	2.19	4.62	3.65
0.26	4.83	3.45	100.00	16.78	1.93	3.72	12.85	7.18	24.78
	sum	100.00		293.20			44.54		22.70
		3.00		2.93			0.87		0.76
		Mode		*Mean*			*StandDev*		*Skewness*



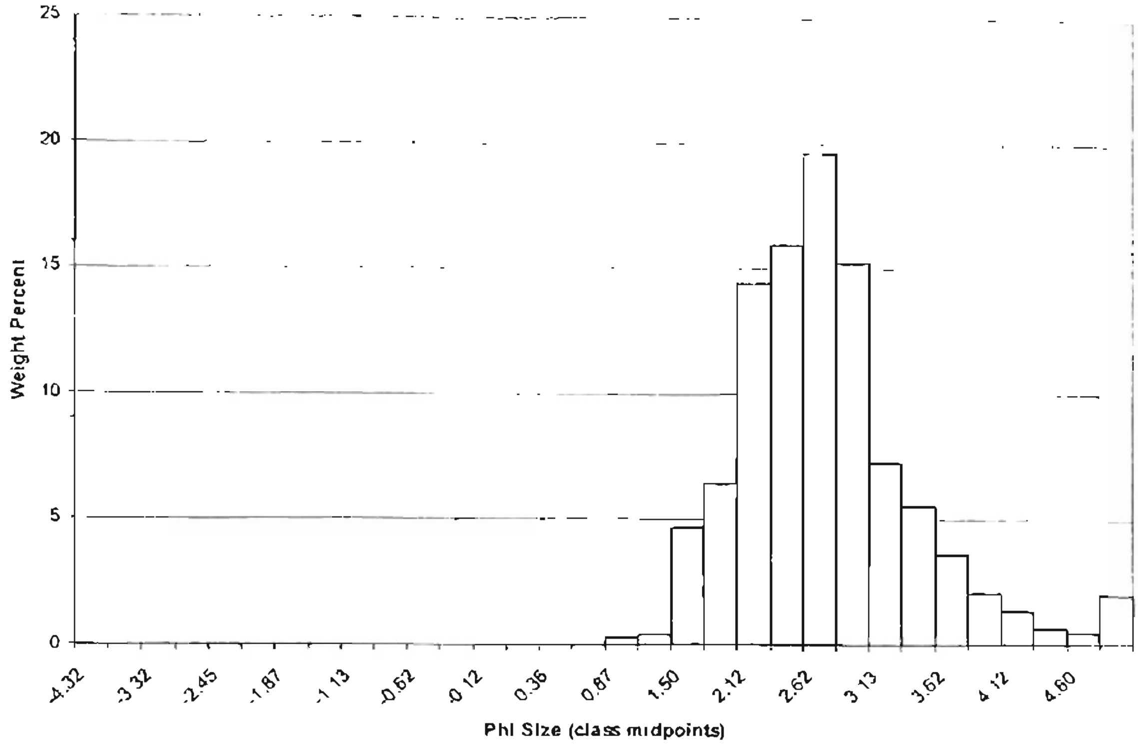
Weight Percent
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

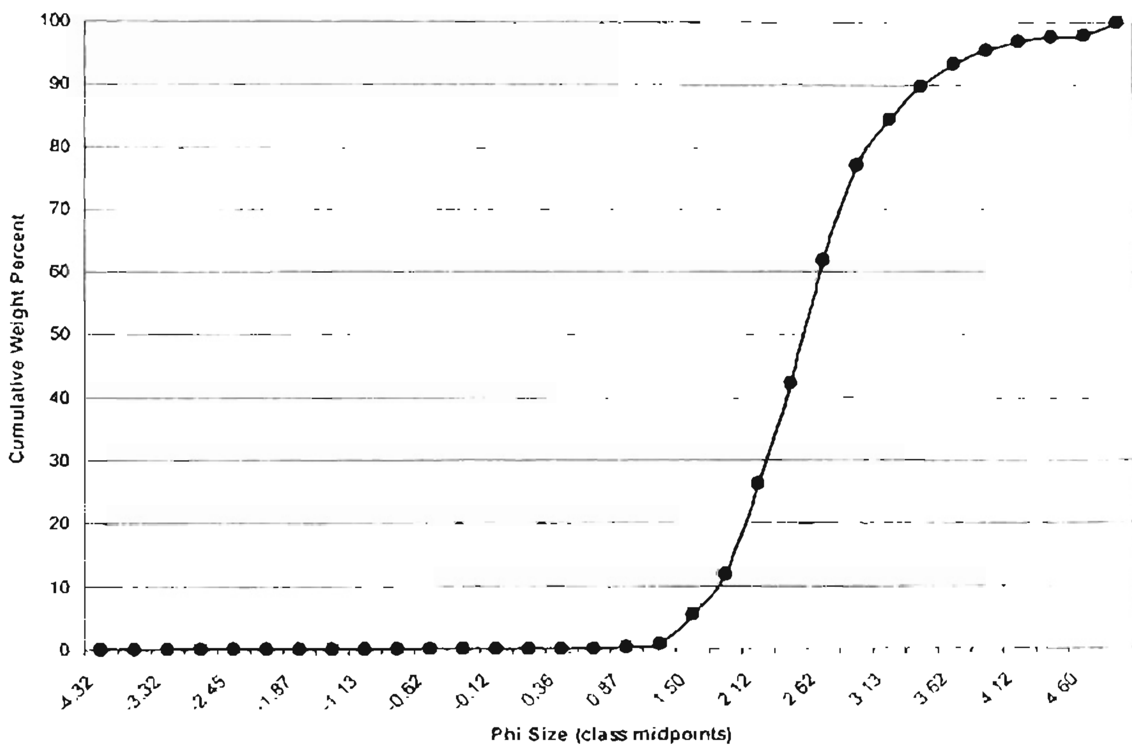


Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Franklin Street, 0.1 miles east of Pebbly Road

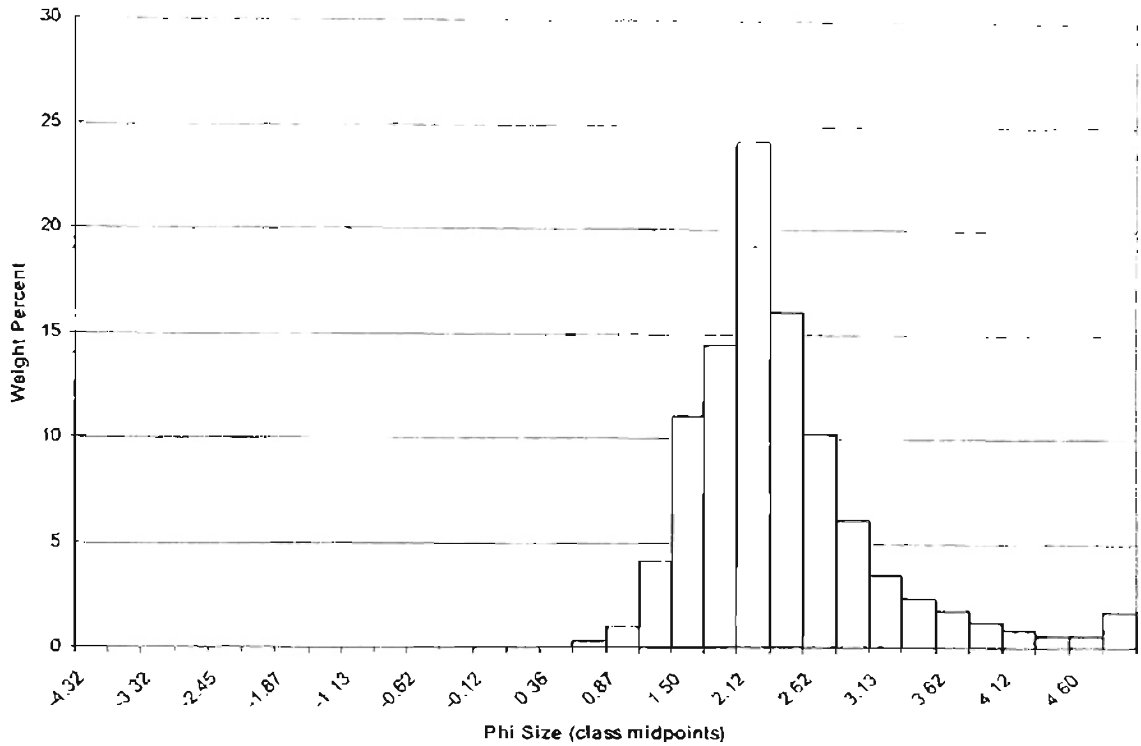
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.98	48.75	0.00	-340.35	0.00
0.50	-3.82	0.00	0.00	0.00	-6.48	42.07	0.00	-272.34	0.00
0.50	-3.32	0.00	0.00	0.00	-5.98	35.76	0.00	-214.05	0.00
0.49	-2.83	0.00	0.00	0.00	-5.49	30.11	0.00	-165.26	0.00
0.38	-2.45	0.00	0.00	0.00	-5.11	26.13	0.00	-133.56	0.00
0.33	-2.12	0.00	0.00	0.00	-4.78	22.89	0.00	-109.49	0.00
0.25	-1.87	0.00	0.00	0.00	-4.53	20.58	0.00	-93.22	0.00
0.37	-1.50	0.00	0.00	0.00	-4.16	17.30	0.00	-71.98	0.00
0.37	-1.13	0.00	0.00	0.00	-3.79	14.33	0.00	-54.25	0.00
0.25	-0.87	0.00	0.00	0.00	-3.53	12.49	0.00	-44.15	0.00
0.26	-0.62	0.00	0.00	0.00	-3.28	10.77	0.00	-35.35	0.00
0.25	-0.37	0.00	0.00	0.00	-3.03	9.16	0.00	-27.74	0.00
0.25	-0.12	0.00	0.00	0.00	-2.78	7.73	0.00	-21.47	0.00
0.24	0.12	0.00	0.00	0.00	-2.54	6.47	0.00	-16.44	0.00
0.25	0.36	0.00	0.00	0.00	-2.30	5.27	0.00	12.10	0.00
0.25	0.62	0.00	0.00	0.00	-2.04	4.16	0.00	-8.55	0.00
0.25	0.87	0.31	0.31	0.27	-1.79	3.21	0.99	-5.75	-1.78
0.25	1.12	0.41	0.72	0.46	-1.54	2.36	0.98	-3.67	-1.51
0.38	1.50	4.67	5.39	6.99	-1.16	1.35	6.31	-1.57	-7.33
0.38	1.88	6.42	11.81	12.07	-0.78	0.61	3.90	-0.47	-3.04
0.24	2.12	14.43	26.24	30.56	-0.54	0.29	4.22	-0.16	-2.29
0.25	2.37	15.97	42.21	37.82	-0.29	0.09	1.36	-0.02	-0.40
0.25	2.62	19.62	61.83	51.45	-0.04	0.00	0.03	0.00	0.00
0.25	2.87	15.25	77.08	43.82	0.21	0.05	0.69	0.01	0.15
0.25	3.13	7.24	84.32	22.63	0.47	0.22	1.57	0.10	0.73
0.25	3.36	5.55	89.87	18.75	0.72	0.52	2.87	0.37	2.06
0.24	3.62	3.60	93.47	13.04	0.96	0.92	3.33	0.89	3.20
0.25	3.87	2.05	95.52	7.93	1.21	1.48	2.99	1.76	3.62
0.25	4.12	1.34	96.85	5.52	1.46	2.13	2.85	3.11	4.16
0.24	4.36	0.67	97.53	2.92	1.70	2.89	1.93	4.88	3.27
0.24	4.60	0.45	97.99	2.11	1.94	3.76	1.72	7.26	3.34
0.26	4.86	2.00	99.99	9.72	2.20	4.84	9.67	10.63	21.26
	sum	99.99		266.08			45.42		25.45
		2.75		2.66			0.67		0.83
		Mode		*Mean*			*StandDev*		*Skewness*


25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

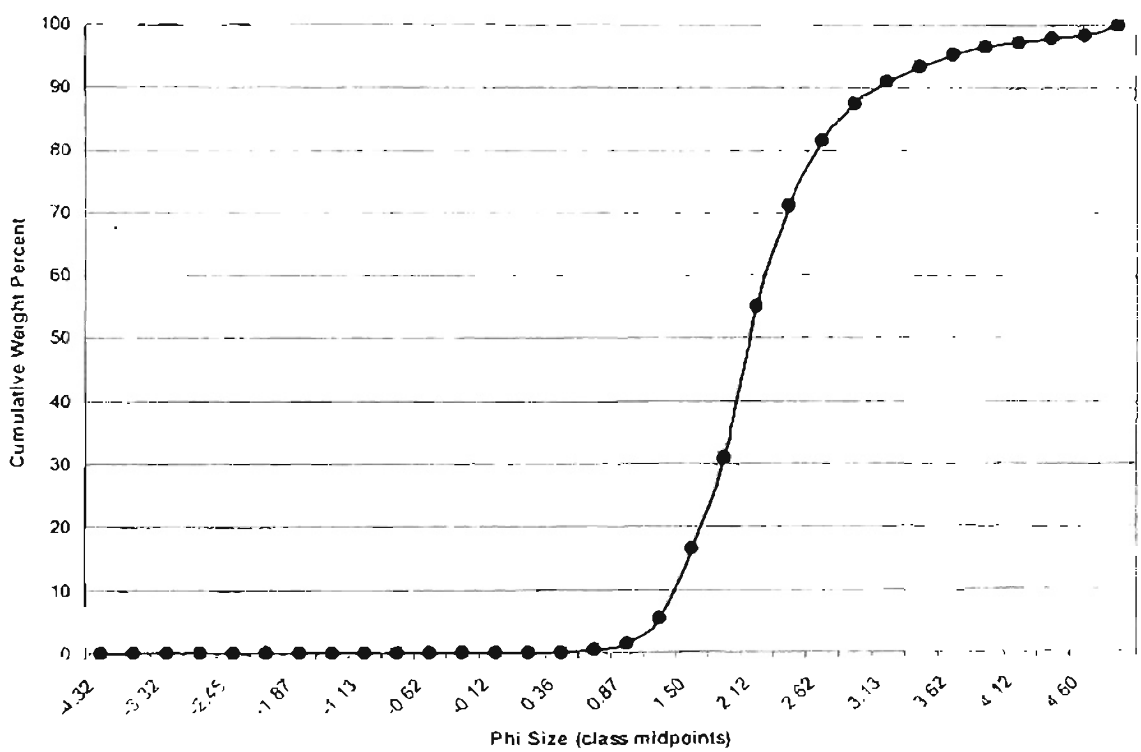

100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Franklin Street, 0.5 miles east of Pebbly Road

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.62	43.85	0.00	-290.37	0.00
0.50	-3.82	0.00	0.00	0.00	-6.12	37.48	0.00	-229.44	0.00
0.50	-3.32	0.00	0.00	0.00	-5.82	31.81	0.00	-177.89	0.00
0.49	-2.83	0.00	0.00	0.00	-5.13	26.29	0.00	-134.82	0.00
0.38	-2.45	0.00	0.00	0.00	4.75	22.58	0.00	-107.28	0.00
0.33	-2.12	0.00	0.00	0.00	-4.42	19.57	0.00	-86.58	0.00
0.25	-1.87	0.00	0.00	0.00	-4.17	17.42	0.00	-72.73	0.00
0.37	-1.50	0.00	0.00	0.00	-3.80	14.44	0.00	-54.86	0.00
0.37	-1.13	0.00	0.00	0.00	-3.43	11.73	0.00	-40.19	0.00
0.25	-0.87	0.00	0.00	0.00	-3.17	10.08	0.00	-31.98	0.00
0.25	-0.62	0.00	0.00	0.00	-2.92	8.54	0.00	-24.95	0.00
0.25	-0.37	0.00	0.00	0.00	-2.67	7.11	0.00	-18.98	0.00
0.25	-0.12	0.00	0.00	0.00	-2.42	5.85	0.00	-14.15	0.00
0.24	0.12	0.00	0.00	0.00	-2.18	4.76	0.00	-10.40	0.00
0.25	0.36	0.08	0.08	0.03	-1.94	3.75	0.30	-7.25	-0.58
0.25	0.62	0.29	0.37	0.18	-1.68	2.84	0.82	-4.78	-1.39
0.25	0.87	1.00	1.37	0.87	-1.43	2.05	2.05	-2.93	-2.93
0.25	1.12	4.10	5.47	4.58	-1.18	1.40	5.74	-1.65	-6.78
0.30	1.50	11.00	16.50	16.52	-0.00	0.64	7.10	-0.52	-5.69
0.38	1.88	14.50	31.00	27.27	-0.42	0.18	2.55	-0.07	-1.07
0.24	2.12	24.20	55.20	51.28	-0.18	0.03	0.78	-0.01	-0.14
0.25	2.37	16.01	71.21	37.91	0.07	0.00	0.07	0.00	0.01
0.25	2.62	10.24	81.45	26.85	0.32	0.10	1.06	0.03	0.34
0.25	2.87	6.10	87.55	17.53	0.57	0.33	2.00	0.19	1.15
0.25	3.13	3.47	91.02	10.85	0.83	0.68	2.37	0.56	1.95
0.25	3.38	2.34	93.36	7.91	1.08	1.16	2.72	1.26	2.94
0.24	3.62	1.80	95.16	6.52	1.32	1.75	3.14	2.31	4.16
0.25	3.87	1.21	96.37	4.68	1.57	2.46	2.98	3.86	4.67
0.25	4.12	0.84	97.21	3.46	1.82	3.31	2.78	6.02	5.06
0.24	4.36	0.59	97.80	2.57	2.06	4.23	2.49	8.69	5.13
0.24	4.60	0.54	98.34	2.48	2.30	5.27	2.85	12.10	6.54
0.28	4.88	1.37	100.01	8.11	2.58	8.55	10.94	10.78	27.98
	sum	100.01		229.80			52.76		41.32
		2.24		2.30			0.73		1.08
		Mode		Mean			StandDev		Skewness



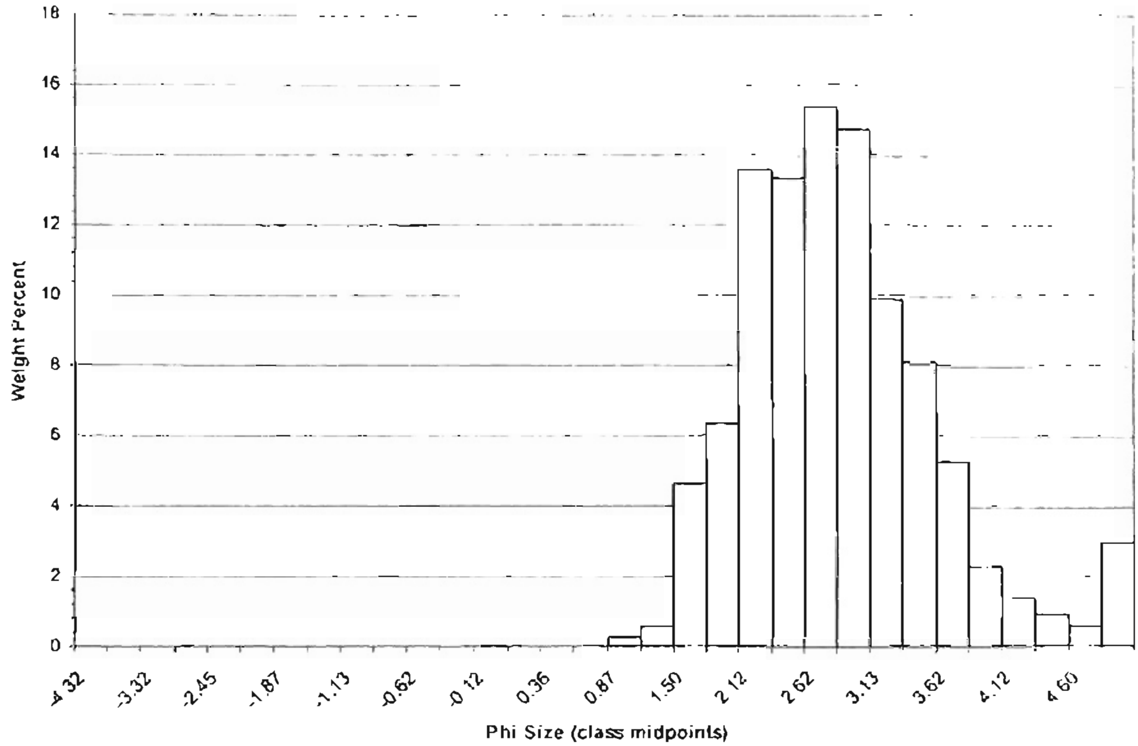
Weight Percent
30
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



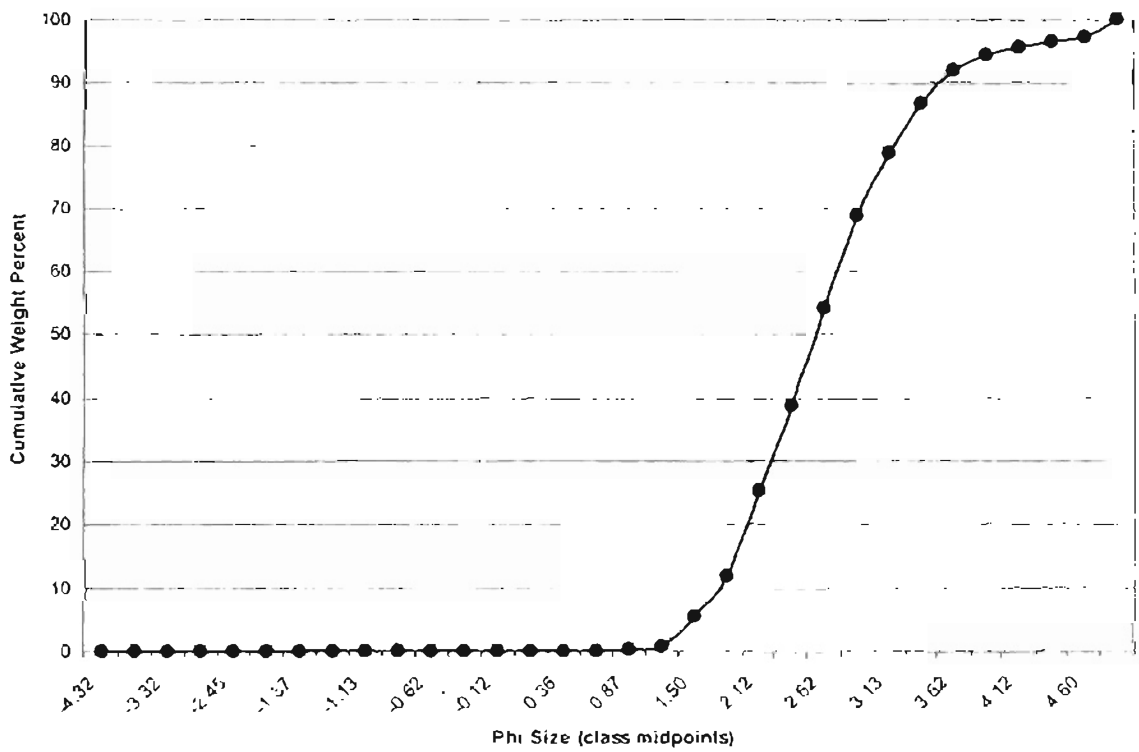
Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Franklin Street, 2.6 miles east of Pebbly Road

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.07	50.01	0.00	-353.68	0.00
0.50	-3.82	0.00	0.00	0.00	-6.57	43.19	0.00	-283.84	0.00
0.50	3.32	0.00	0.00	0.00	6.07	36.87	0.00	223.96	0.00
0.49	-2.83	0.00	0.00	0.00	-5.58	31.11	0.00	-173.52	0.00
0.38	-2.45	0.00	0.00	0.00	-5.20	27.06	0.00	-140.74	0.00
0.33	-2.12	0.00	0.00	0.00	-4.87	23.76	0.00	-115.78	0.00
0.25	-1.87	0.00	0.00	0.00	-4.62	21.38	0.00	-98.88	0.00
0.37	-1.50	0.00	0.00	0.00	-4.25	18.06	0.00	-76.75	0.00
0.37	-1.13	0.00	0.00	0.00	-3.88	15.02	0.00	-58.21	0.00
0.25	-0.87	0.00	0.00	0.00	-3.62	13.14	0.00	-47.60	0.00
0.25	-0.62	0.00	0.00	0.00	-3.37	11.37	0.00	-38.34	0.00
0.25	-0.37	0.00	0.00	0.00	-3.12	9.72	0.00	-30.29	0.00
0.25	-0.12	0.00	0.00	0.00	-2.87	8.23	0.00	-23.62	0.00
0.24	0.12	0.00	0.00	0.00	-2.63	6.93	0.00	-18.25	0.00
0.25	0.36	0.00	0.00	0.00	-2.39	5.69	0.00	-13.58	0.00
0.25	0.62	0.00	0.00	0.00	-2.13	4.56	0.00	-9.72	0.00
0.25	0.87	0.27	0.27	0.23	-1.88	3.54	0.93	-6.66	-1.80
0.25	1.12	0.55	0.82	0.61	-1.63	2.67	1.47	-4.35	-2.39
0.38	1.50	4.62	5.44	6.92	-1.25	1.57	7.24	-1.96	-9.07
0.38	1.88	6.36	11.80	11.96	-0.87	0.76	4.81	-0.66	-4.18
0.24	2.12	13.59	25.39	28.80	-0.63	0.40	5.41	-0.25	-3.42
0.25	2.37	13.31	38.70	31.52	-0.38	0.15	1.94	-0.06	-0.74
0.25	2.62	15.37	54.07	40.31	-0.13	0.02	0.25	0.00	-0.03
0.25	2.87	14.73	68.80	42.32	0.12	0.02	0.22	0.00	0.03
0.25	3.13	9.88	78.68	30.88	0.38	0.14	1.40	0.05	0.52
0.25	3.38	8.10	86.78	27.37	0.63	0.40	3.23	0.25	2.02
0.24	3.62	5.22	92.00	18.91	0.87	0.76	3.97	0.66	3.46
0.25	3.87	2.24	94.24	8.67	1.12	1.25	2.83	1.40	3.13
0.25	4.12	1.37	95.61	5.64	1.37	1.87	2.57	2.57	3.51
0.24	4.36	0.91	96.52	3.96	1.61	2.58	2.35	4.14	3.77
0.24	4.60	0.55	97.07	2.53	1.85	3.41	1.87	6.29	3.46
0.26	4.86	2.93	100.00	14.24	2.11	4.45	13.03	9.38	27.48
	sum	100.00		274.87			53.49		25.75
		2.75		2.75			0.73		0.00
		Mode		Mean			StandDev		Skewness



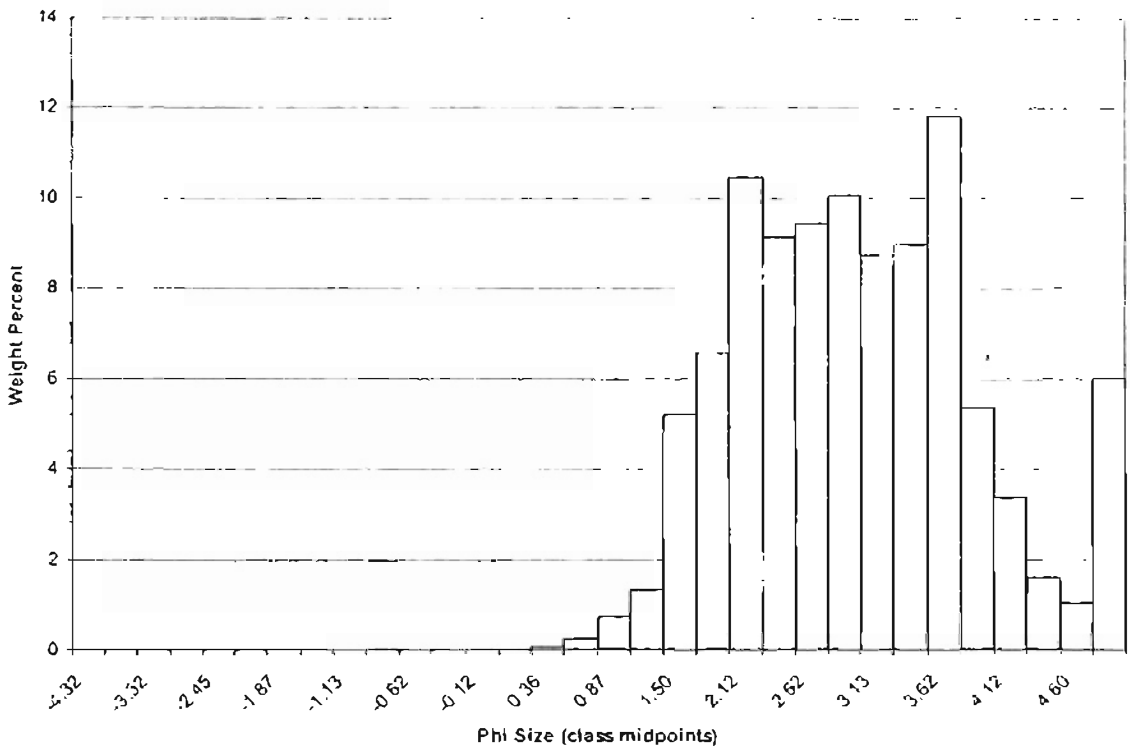
Weight Percent
Phi Size (class midpoints)

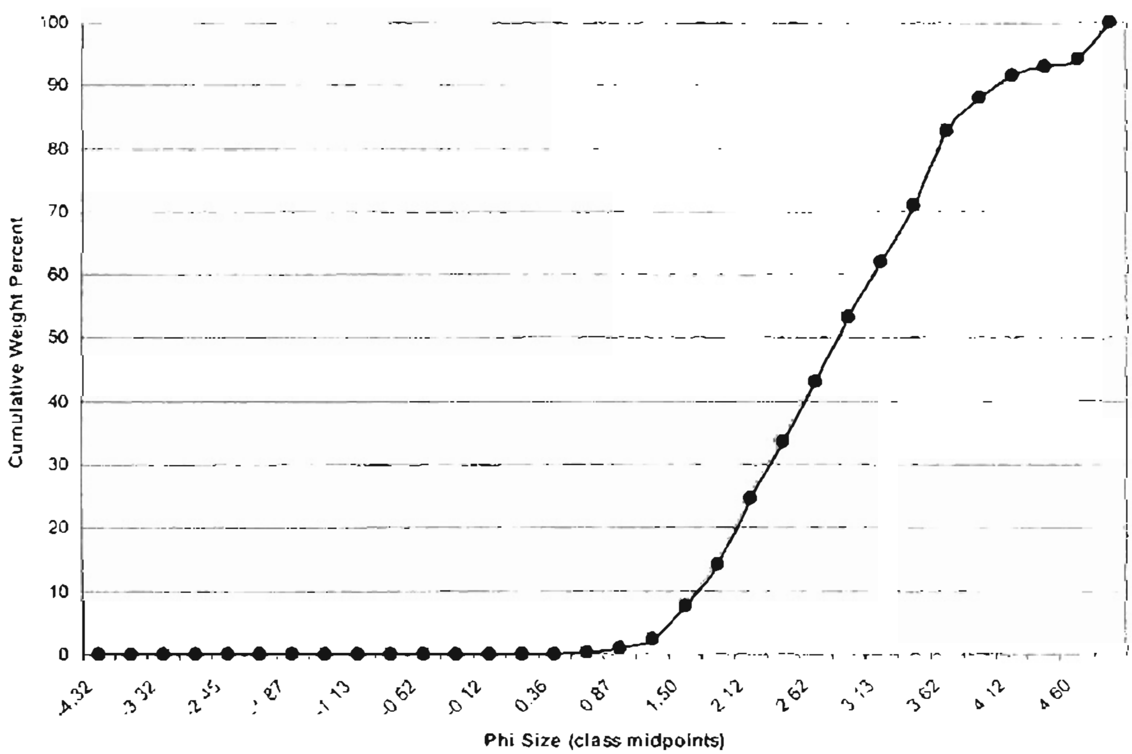


Cumulative Weight Percent
Phi Size (class midpoints)

Franklin Street, 3.2 miles east of Pebbly Road

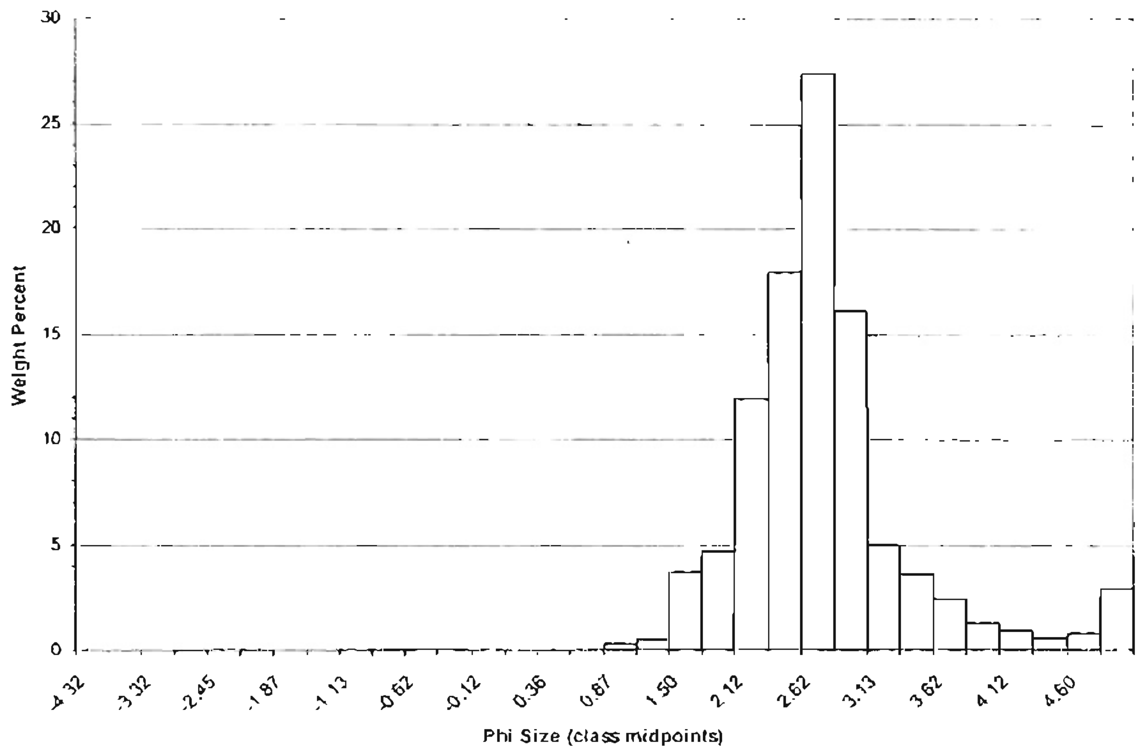
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interva	-4.32	0.00	0.00	0.00	-7.28	53.03	0.00	-386.13	0.00
0.50	-3.82	0.00	0.00	0.00	-6.78	45.93	0.00	-311.03	0.00
0.50	-3.32	0.00	0.00	0.00	-6.28	39.43	0.00	-247.90	0.00
0.49	-2.83	0.00	0.00	0.00	-5.79	33.53	0.00	-193.87	0.00
0.38	-2.45	0.00	0.00	0.00	-5.41	29.23	0.00	-158.48	0.00
0.33	-2.12	0.00	0.00	0.00	-5.08	25.85	0.00	-131.40	0.00
0.25	-1.87	0.00	0.00	0.00	-4.83	23.37	0.00	-112.97	0.00
0.37	-1.50	0.00	0.00	0.00	-4.46	19.89	0.00	-88.70	0.00
0.37	-1.13	0.00	0.00	0.00	-4.09	16.63	0.00	-68.19	0.00
0.25	-0.87	0.00	0.00	0.00	-3.83	14.70	0.00	-56.37	0.00
0.25	-0.62	0.00	0.00	0.00	-3.58	12.83	0.00	-45.96	0.00
0.25	-0.37	0.00	0.00	0.00	-3.33	11.07	0.00	36.83	0.00
0.25	-0.12	0.00	0.00	0.00	-3.08	9.43	0.00	-29.20	0.00
0.24	0.12	0.00	0.00	0.00	-2.84	8.03	0.00	-22.87	0.00
0.25	0.36	0.06	0.06	0.02	-2.60	6.74	0.40	-17.49	-1.05
0.25	0.62	0.23	0.29	0.14	-2.34	5.50	1.26	-12.89	-2.96
0.25	0.87	0.74	1.03	0.64	-2.09	4.37	3.24	-9.15	-6.77
0.25	1.12	1.31	2.34	1.46	-1.84	3.40	4.45	-6.26	-8.20
0.38	1.50	5.19	7.53	7.77	-1.46	2.14	11.10	-3.13	-16.22
0.38	1.88	6.56	14.09	12.34	-1.08	1.17	7.64	-1.26	-8.25
0.24	2.12	10.45	24.54	22.14	-0.84	0.71	7.39	-0.59	-6.22
0.25	2.37	9.13	33.67	21.62	-0.59	0.35	3.20	-0.21	-1.89
0.25	2.62	9.42	43.09	24.70	-0.34	0.11	1.07	-0.04	-0.36
0.25	2.87	10.05	53.14	28.88	-0.09	0.01	0.08	0.00	-0.01
0.25	3.13	8.73	61.87	27.29	0.17	0.03	0.24	0.00	0.04
0.25	3.38	8.98	70.83	30.28	0.42	0.18	1.57	0.07	0.66
0.24	3.62	11.82	82.65	42.81	0.66	0.44	5.17	0.29	3.42
0.25	3.87	5.37	88.02	20.77	0.91	0.83	4.43	0.75	4.03
0.25	4.12	3.37	91.39	13.88	1.16	1.34	4.53	1.56	5.25
0.24	4.36	1.60	92.99	6.97	1.40	1.95	3.12	2.72	4.35
0.24	4.60	1.03	94.02	4.73	1.64	2.83	2.76	4.38	4.51
0.26	4.86	5.99	100.01	29.10	1.90	3.61	21.60	6.85	41.02
	sum	100.01		295.56			83.25		11.34
		3.74		2.96			0.91		0.15
		Mode		*Mean*			*StandDev*		*Skewness*

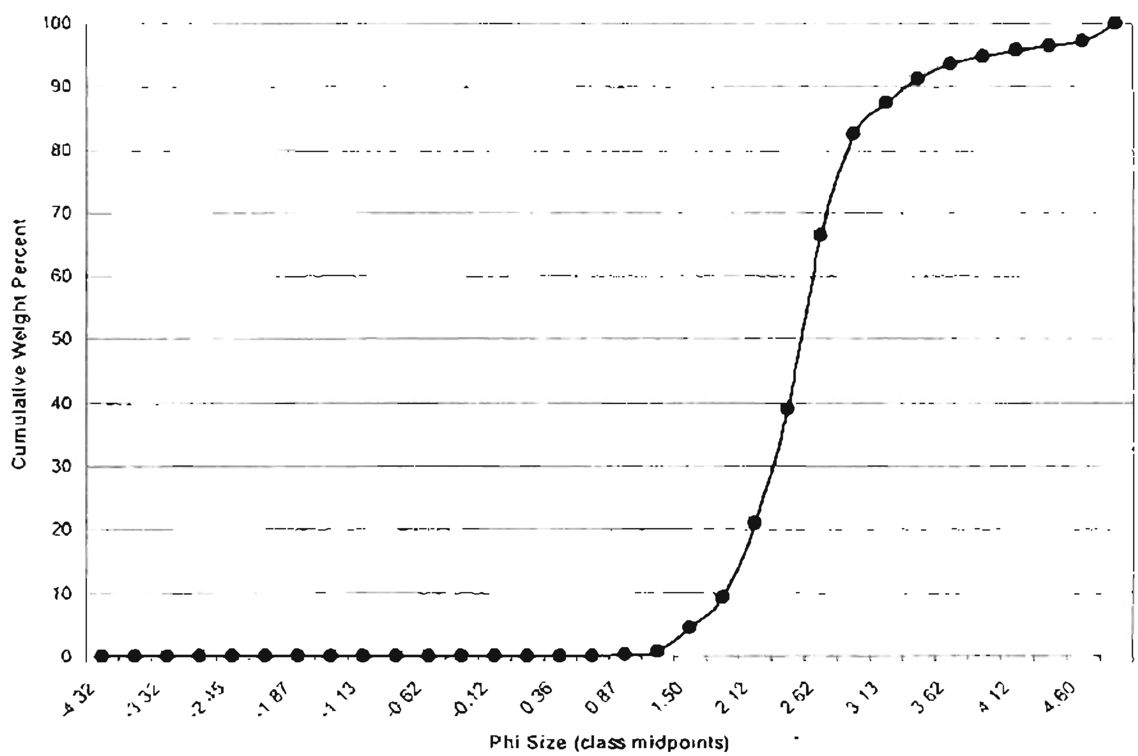

Weight Percent
Phi Size (class midpoints)


Cumulative Weight Percent
Phi Size (class midpoints)

Franklin Street, 4.3 miles east of Pebbly Road

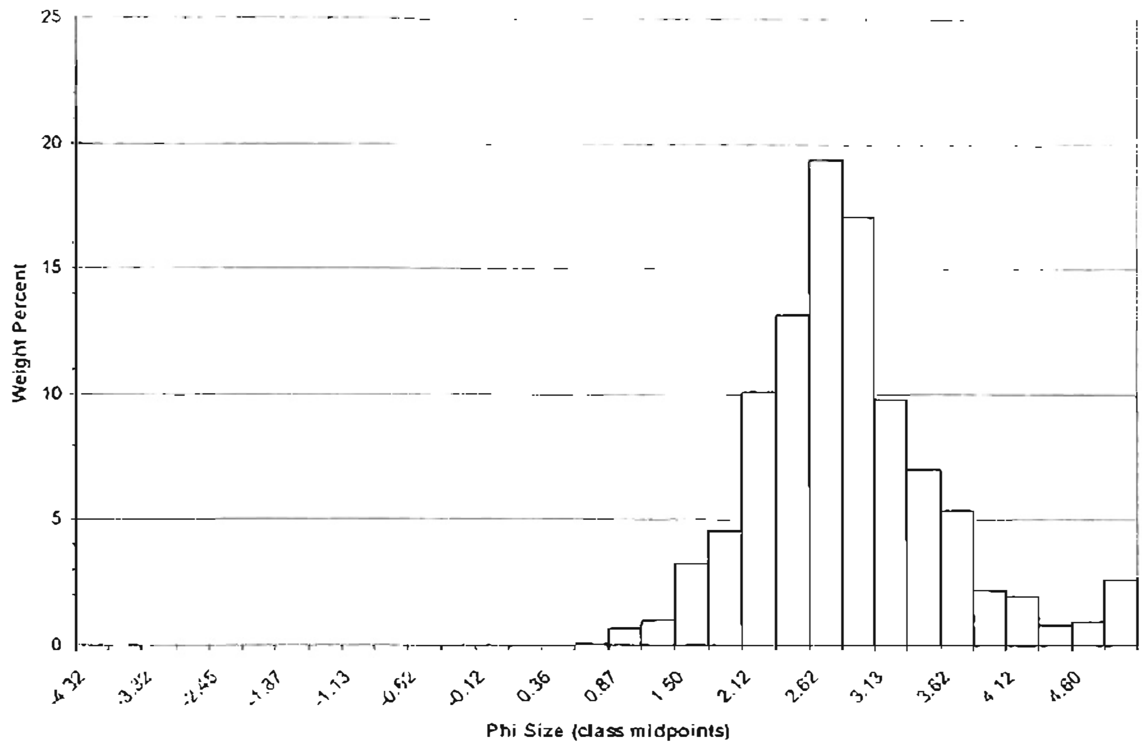
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.98	48.75	0.00	-340.35	0.00
0.50	-3.82	0.00	0.00	0.00	-6.48	42.02	0.00	-272.34	0.00
0.50	-3.32	0.00	0.00	0.00	-5.98	35.79	0.00	-214.05	0.00
0.49	-2.83	0.00	0.00	0.00	-5.49	30.11	0.00	-165.26	0.00
0.38	-2.45	0.00	0.00	0.00	-5.11	26.13	0.00	-133.56	0.00
0.33	-2.12	0.00	0.00	0.00	-4.78	22.80	0.00	-109.40	0.00
0.25	-1.87	0.00	0.00	0.00	-4.53	20.56	0.00	-93.22	0.00
0.37	-1.50	0.00	0.00	0.00	-4.16	17.30	0.00	-71.98	0.00
0.37	-1.13	0.00	0.00	0.00	-3.79	14.33	0.00	-54.25	0.00
0.25	-0.87	0.00	0.00	0.00	-3.53	12.49	0.00	-44.15	0.00
0.25	-0.62	0.00	0.00	0.00	-3.28	10.77	0.00	-35.35	0.00
0.25	0.37	0.00	0.00	0.00	3.03	9.16	0.00	27.74	0.00
0.25	-0.12	0.00	0.00	0.00	-2.78	7.73	0.00	-21.47	0.00
0.24	0.12	0.00	0.00	0.00	-2.54	6.47	0.00	-16.44	0.00
0.25	0.36	0.00	0.00	0.00	-2.30	5.27	0.00	-12.10	0.00
0.25	0.62	0.00	0.00	0.00	-2.04	4.18	0.00	-8.55	0.00
0.25	0.87	0.30	0.30	0.26	-1.79	3.21	0.96	-5.75	-1.72
0.25	1.12	0.50	0.80	0.56	-1.54	2.38	1.19	-3.67	-1.84
0.38	1.50	3.70	4.50	5.54	-1.16	1.35	5.00	-1.57	-5.81
0.38	1.88	4.65	9.15	8.74	-0.78	0.61	2.82	-0.47	-2.20
0.24	2.12	11.91	21.06	25.24	-0.54	0.29	3.49	-0.16	-1.89
0.25	2.37	17.96	39.02	42.53	-0.29	0.09	1.53	-0.02	-0.45
0.25	2.62	27.41	66.43	71.88	-0.04	0.00	0.04	0.00	0.00
0.25	2.87	16.11	82.54	46.29	0.21	0.05	0.73	0.01	0.15
0.25	3.13	4.95	87.49	15.47	0.47	0.22	1.07	0.10	0.50
0.25	3.38	3.65	91.14	12.33	0.72	0.52	1.89	0.37	1.36
0.24	3.62	2.40	93.54	8.69	0.96	0.92	2.22	0.89	2.13
0.25	3.87	1.30	94.84	5.03	1.21	1.46	1.90	1.76	2.29
0.25	4.12	0.95	95.79	3.91	1.46	2.13	2.02	3.11	2.95
0.24	4.36	0.55	96.34	2.40	1.70	2.88	1.58	4.38	2.68
0.24	4.60	0.75	97.09	3.45	1.94	3.75	2.81	7.26	5.44
0.28	4.86	2.90	99.99	14.09	2.20	4.84	14.02	10.63	30.83
	sum	99.99		286.41			43.28		34.44
		2.75		2.66			0.66		1.21
		Mode		Mean			StandDev		Skewness

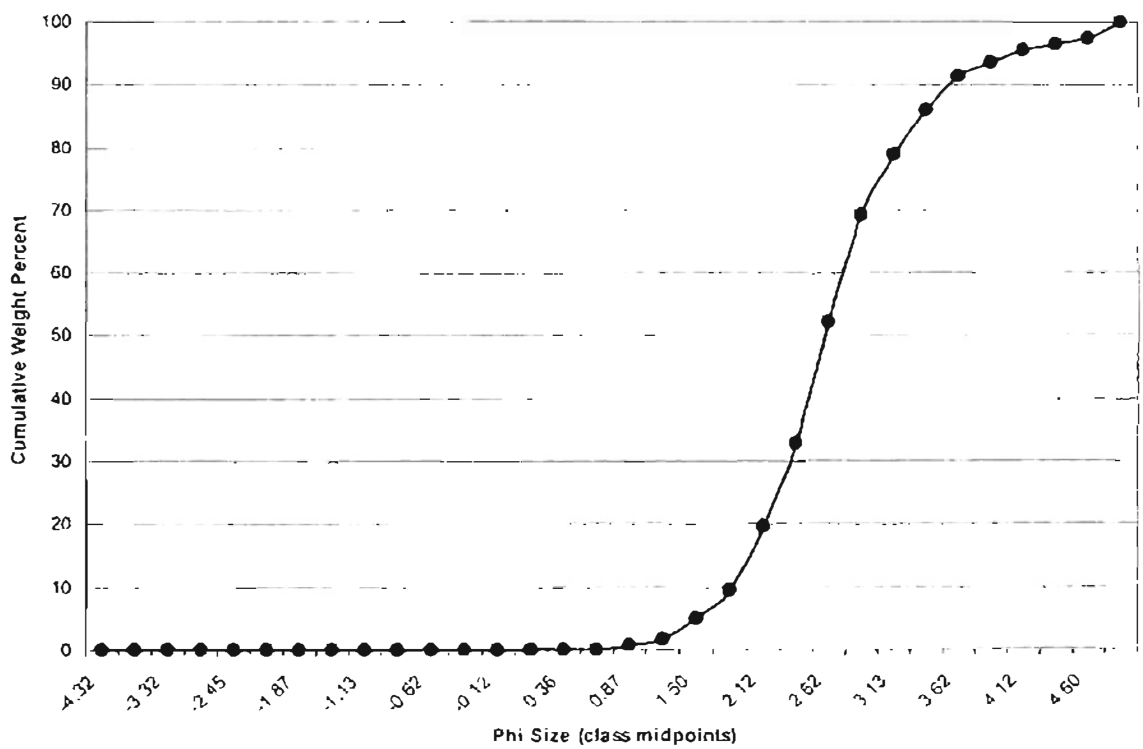

Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60


Cumulative Weight Percent
Phi Size (class midpoints)

Pebbly Road, 2.4 miles north of Little Axe Park entrance

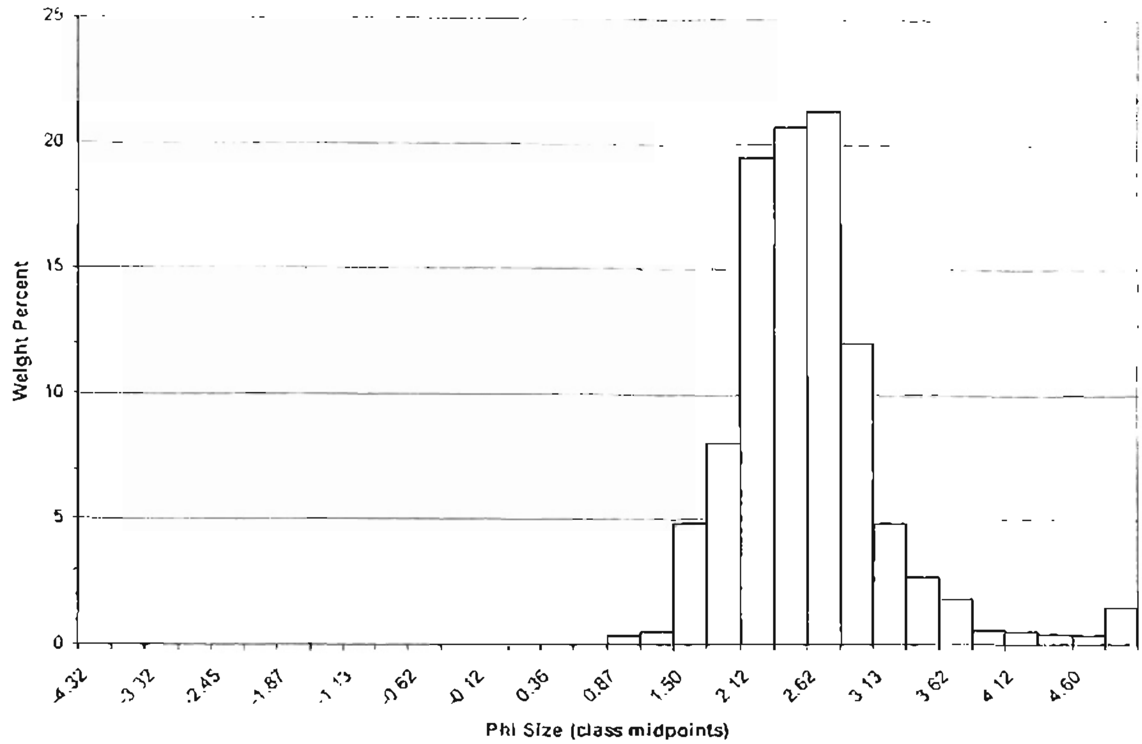
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.11	50.58	0.00	-359.72	0.00
0.50	-3.82	0.00	0.00	0.00	-6.61	43.72	0.00	-289.06	0.00
0.50	-3.32	0.00	0.00	0.00	-6.11	37.36	0.00	228.32	0.00
0.49	-2.83	0.00	0.00	0.00	-5.62	31.56	0.00	177.28	0.00
0.38	-2.45	0.00	0.00	0.00	-5.24	27.47	0.00	-144.01	0.00
0.33	-2.12	0.00	0.00	0.00	-4.91	24.15	0.00	-118.66	0.00
0.25	-1.87	0.00	0.00	0.00	-4.66	21.76	0.00	-101.47	0.00
0.37	-1.50	0.00	0.00	0.00	-4.29	18.40	0.00	-78.94	0.00
0.37	-1.13	0.00	0.00	0.00	-3.92	15.33	0.00	-60.03	0.00
0.25	-0.87	0.00	0.00	0.00	-3.66	13.43	0.00	-49.20	0.00
0.25	-0.62	0.00	0.00	0.00	-3.41	11.64	0.00	-39.72	0.00
0.25	-0.37	0.00	0.00	0.00	-3.16	9.97	0.00	-31.47	0.00
0.25	-0.12	0.00	0.00	0.00	-2.91	8.46	0.00	-24.63	0.00
0.24	0.12	0.00	0.00	0.00	-2.67	7.14	0.00	-19.09	0.00
0.25	0.36	0.00	0.00	0.00	-2.43	5.88	0.00	-14.27	0.00
0.25	0.62	0.03	0.03	0.02	-2.17	4.73	0.14	-10.28	-0.31
0.25	0.87	0.67	0.70	0.58	-1.92	3.69	2.47	-7.09	-4.75
0.25	1.12	1.01	1.71	1.13	-1.67	2.80	2.83	-4.68	-4.73
0.38	1.50	3.28	4.99	4.91	-1.29	1.67	5.48	-2.16	-7.08
0.38	1.88	4.57	9.58	8.59	-0.91	0.83	3.78	-0.75	-3.44
0.24	2.12	10.09	19.65	21.38	-0.67	0.45	4.54	-0.30	-3.05
0.25	2.37	13.16	32.81	31.16	-0.42	0.18	2.34	-0.08	-0.99
0.25	2.62	19.36	52.17	50.77	-0.17	0.03	0.54	0.00	-0.09
0.25	2.87	17.06	69.23	49.02	0.08	0.01	0.12	0.00	0.01
0.25	3.13	9.79	79.02	30.60	0.34	0.11	1.10	0.04	0.37
0.25	3.38	7.02	86.04	23.72	0.59	0.35	2.43	0.20	1.43
0.24	3.62	5.40	91.44	19.56	0.83	0.69	3.73	0.58	3.11
0.25	3.87	2.21	93.65	8.55	1.08	1.16	2.57	1.25	2.77
0.25	4.12	1.96	95.61	8.07	1.33	1.77	3.46	2.35	4.60
0.24	4.36	0.83	96.44	3.62	1.57	2.45	2.04	3.84	3.19
0.24	4.60	0.95	97.39	4.37	1.81	3.26	3.10	5.89	5.60
0.26	4.86	2.61	100.00	12.68	2.07	4.28	11.17	8.86	23.11
	sum	100.00		278.73			51.86		19.76
		2.75		2.79			0.72		0.53
		Mode		Mean			StandDev		Skewness

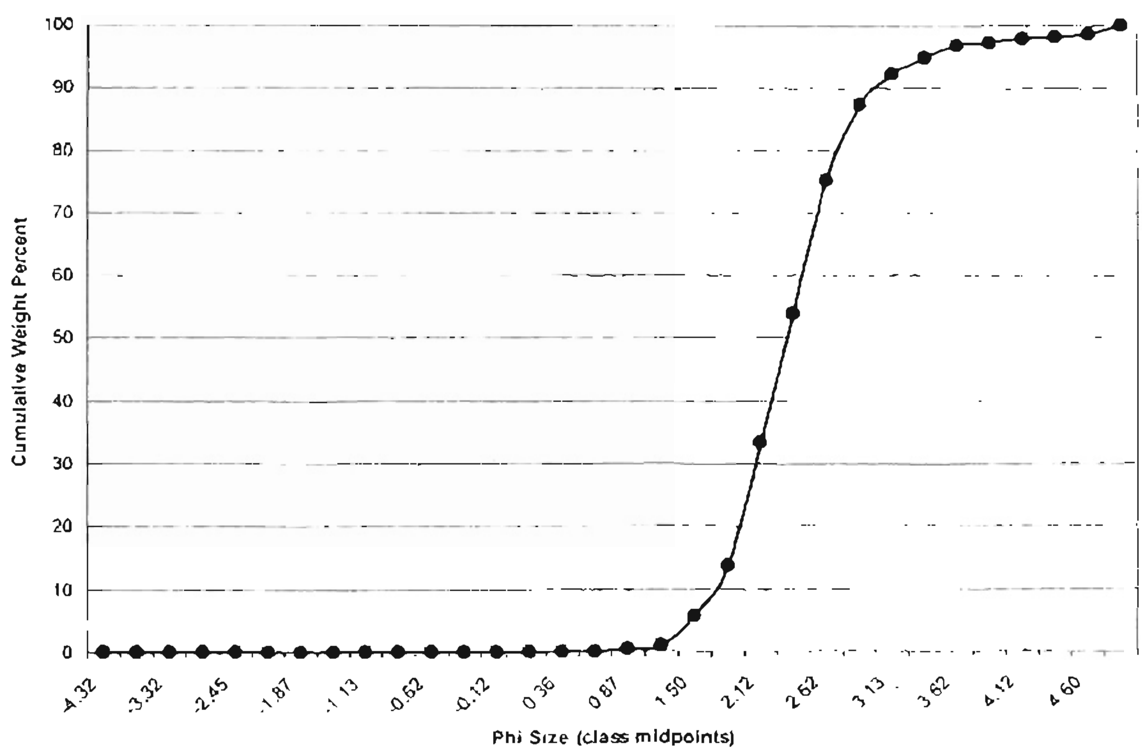

Weight Percent
Phi Size (class midpoints)


Cumulative Weight Percent
Phi Size (class midpoints)

Pebbly Road, 4.6 miles north of Little Axe Park entrance

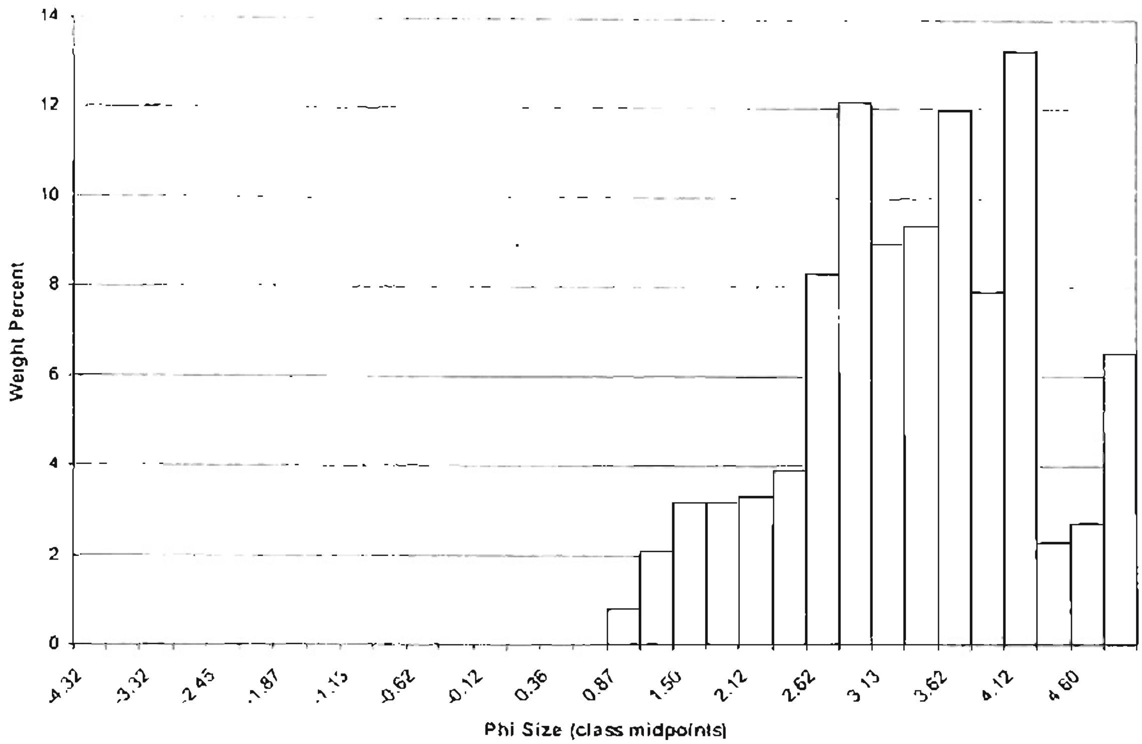
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	*f*		*fm*	*m-x*	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.82	46.54	0.00	-317.48	0.00
0.50	-3.82	0.00	0.00	0.00	-6.32	39.97	0.00	-252.67	0.00
0.50	-3.32	0.00	0.00	0.00	-5.82	33.89	0.00	-197.33	0.00
0.49	-2.83	0.00	0.00	0.00	-5.33	28.38	0.00	-151.22	0.00
0.38	-2.45	0.00	0.00	0.00	-4.95	24.52	0.00	-121.41	0.00
0.23	-2.12	0.00	0.00	0.00	-4.62	21.38	0.00	-98.87	0.00
0.25	-1.87	0.00	0.00	0.00	-4.37	19.13	0.00	-83.70	0.00
0.37	-1.50	0.00	0.00	0.00	-4.00	16.00	0.00	-63.99	0.00
0.37	-1.13	0.00	0.00	0.00	-3.63	13.14	0.00	-47.65	0.00
0.25	-0.87	0.00	0.00	0.00	-3.37	11.39	0.00	-38.42	0.00
0.25	-0.62	0.00	0.00	0.00	-3.12	9.75	0.00	-30.43	0.00
0.25	-0.37	0.00	0.00	0.00	-2.87	8.22	0.00	-23.57	0.00
0.25	-0.12	0.00	0.00	0.00	-2.62	6.86	0.00	-17.97	0.00
0.24	0.12	0.00	0.00	0.00	-2.38	5.68	0.00	-13.53	0.00
0.25	0.36	0.00	0.00	0.00	-2.14	4.56	0.00	-9.74	0.00
0.25	0.62	0.00	0.00	0.00	-1.88	3.55	0.00	-6.69	0.00
0.25	0.87	0.36	0.36	0.31	-1.63	2.66	0.96	-4.34	-1.56
0.25	1.12	0.51	0.37	0.57	-1.38	1.91	0.98	-2.64	-1.35
0.38	1.50	4.86	5.73	7.28	-1.00	1.00	4.88	-1.01	-4.89
0.38	1.88	8.06	13.79	15.16	-0.62	0.38	3.09	-0.24	-1.92
0.24	2.12	19.45	33.24	41.21	-0.38	0.15	2.82	-0.06	-1.08
0.25	2.37	20.66	53.32	48.97	-0.13	0.02	0.36	0.00	-0.05
0.25	2.62	21.34	75.26	55.96	0.12	0.01	0.32	0.00	0.04
0.25	2.87	12.05	87.31	34.62	0.37	0.14	1.68	0.05	0.63
0.25	3.13	4.86	92.17	15.19	0.63	0.39	1.90	0.25	1.19
0.25	3.38	2.65	94.36	9.09	0.88	0.77	2.08	0.68	1.83
0.24	3.62	1.81	96.37	6.56	1.12	1.26	2.28	1.41	2.55
0.25	3.87	0.56	97.25	2.24	1.37	1.87	1.09	2.56	1.49
0.25	4.12	0.51	97.76	2.10	1.62	2.62	1.34	4.24	2.16
0.24	4.36	0.44	98.20	1.92	1.86	3.44	1.52	6.39	2.81
0.24	4.60	0.36	98.56	1.65	2.10	4.39	1.58	9.21	3.31
0.26	4.86	1.45	100.01	7.05	2.36	5.56	8.07	13.13	19.03
	sum	100.01		249.89			34.94		24.21
		2.75		2.50			0.59		1.17
		Mode		*Mean*			*StandDev*		*Skewness*


25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

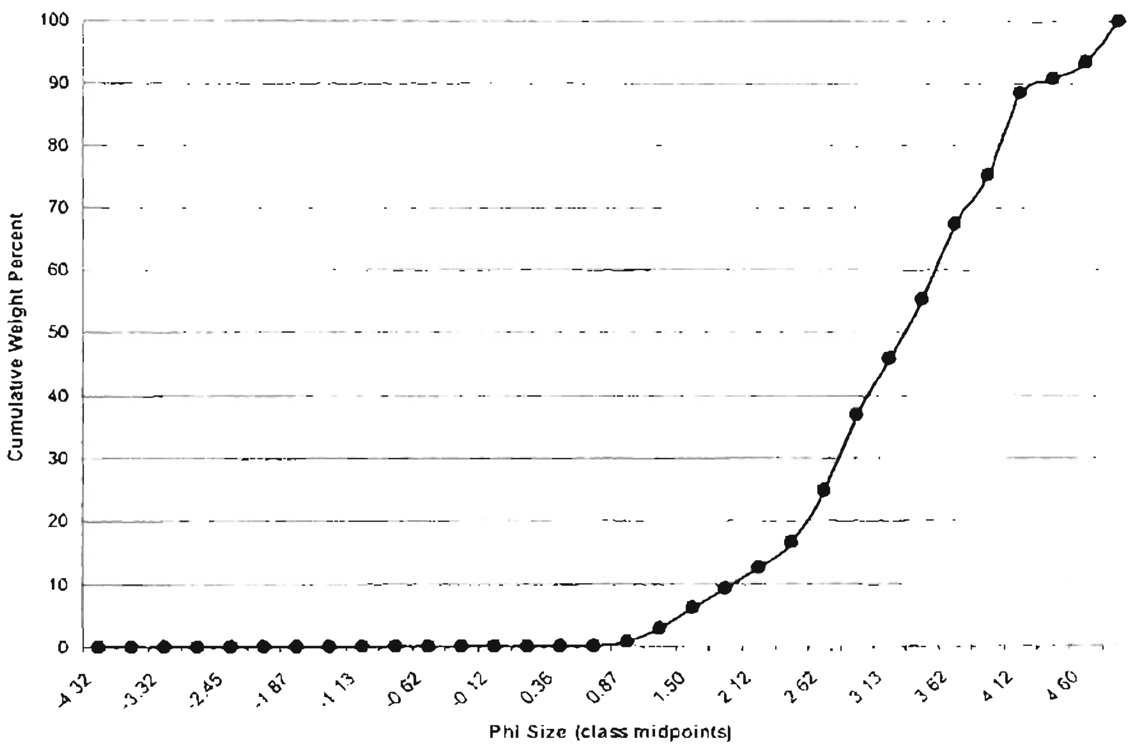

100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Pebbly Road, 4.9 miles north of Little Axe Park entrance

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.61	43.72	0.00	-289.06	0.00
0.50	-3.82	0.00	0.00	0.00	-6.11	37.36	0.00	-228.32	0.00
0.50	-3.32	0.00	0.00	0.00	-5.61	31.49	0.00	-176.74	0.00
0.49	-2.83	0.00	0.00	0.00	5.12	26.19	0.00	-134.04	0.00
0.38	-2.45	0.00	0.00	0.00	4.74	22.48	0.00	-106.61	0.00
0.33	-2.12	0.00	0.00	0.00	-4.41	19.48	0.00	-86.00	0.00
0.25	-1.87	0.00	0.00	0.00	-4.16	17.34	0.00	-72.21	0.00
0.37	-1.50	0.00	0.00	0.00	-3.79	14.36	0.00	-54.43	0.00
0.37	-1.13	0.00	0.00	0.00	-3.42	11.67	0.00	-39.84	0.00
0.25	-0.87	0.00	0.00	0.00	-3.16	10.01	0.00	-31.69	0.00
0.25	-0.62	0.00	0.00	0.00	-2.91	8.48	0.00	-24.70	0.00
0.25	-0.37	0.00	0.00	0.00	-2.66	7.06	0.00	-18.75	0.00
0.25	-0.12	0.00	0.00	0.00	-2.41	5.81	0.00	-13.99	0.00
0.24	0.12	0.00	0.00	0.00	-2.17	4.72	0.00	-10.26	0.00
0.25	0.36	0.00	0.00	0.00	-1.93	3.71	0.00	-7.14	0.00
0.25	0.62	0.00	0.00	0.00	-1.67	2.80	0.00	-4.69	0.00
0.25	0.87	0.80	0.80	0.69	-1.42	2.02	1.62	-2.87	-2.30
0.25	1.12	2.10	2.90	2.35	-1.17	1.38	2.89	-1.61	-3.39
0.38	1.50	3.18	6.08	4.76	-0.79	0.63	2.00	-0.50	-1.58
0.38	1.88	3.18	9.26	5.98	-0.41	0.17	0.53	-0.07	-0.22
0.24	2.12	3.30	12.56	6.99	-0.17	0.03	0.10	-0.01	-0.02
0.25	2.37	3.92	16.48	9.28	0.08	0.01	0.02	0.00	0.00
0.25	2.62	8.30	24.78	21.77	0.33	0.11	0.92	0.04	0.30
0.26	2.87	12.16	36.94	34.94	0.58	0.34	4.14	0.20	2.41
0.25	3.13	8.98	45.92	28.07	0.84	0.70	6.27	0.58	5.24
0.25	3.38	9.38	55.30	31.69	1.09	1.19	11.12	1.29	12.11
0.24	3.62	11.99	67.29	43.42	1.33	1.77	21.26	2.36	28.31
0.25	3.87	7.90	75.19	30.56	1.58	2.49	19.68	3.93	31.07
0.25	4.12	13.30	88.49	54.79	1.83	3.34	44.49	6.12	81.37
0.24	4.36	2.27	90.76	9.89	2.07	4.27	9.69	8.82	20.01
0.24	4.60	2.73	93.49	12.55	2.31	5.32	14.52	12.26	33.47
0.26	4.86	6.53	100.02	31.73	2.57	6.60	43.09	16.95	110.71
	sum	100.02		329.46			182.34		317.52
		4.24		3.29			1.35		1.29
		Mode		Mean			StandDev		Skewness



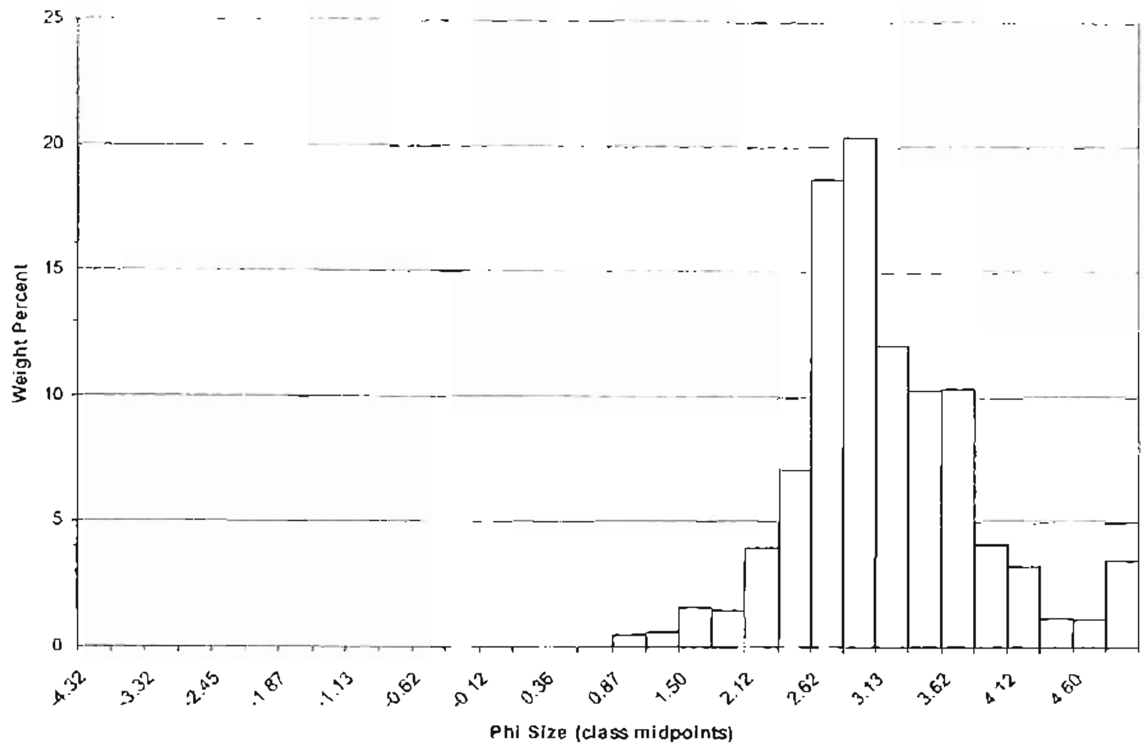
14
12
10
8
6
4
2
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.62
Phi Size (class midpoints)

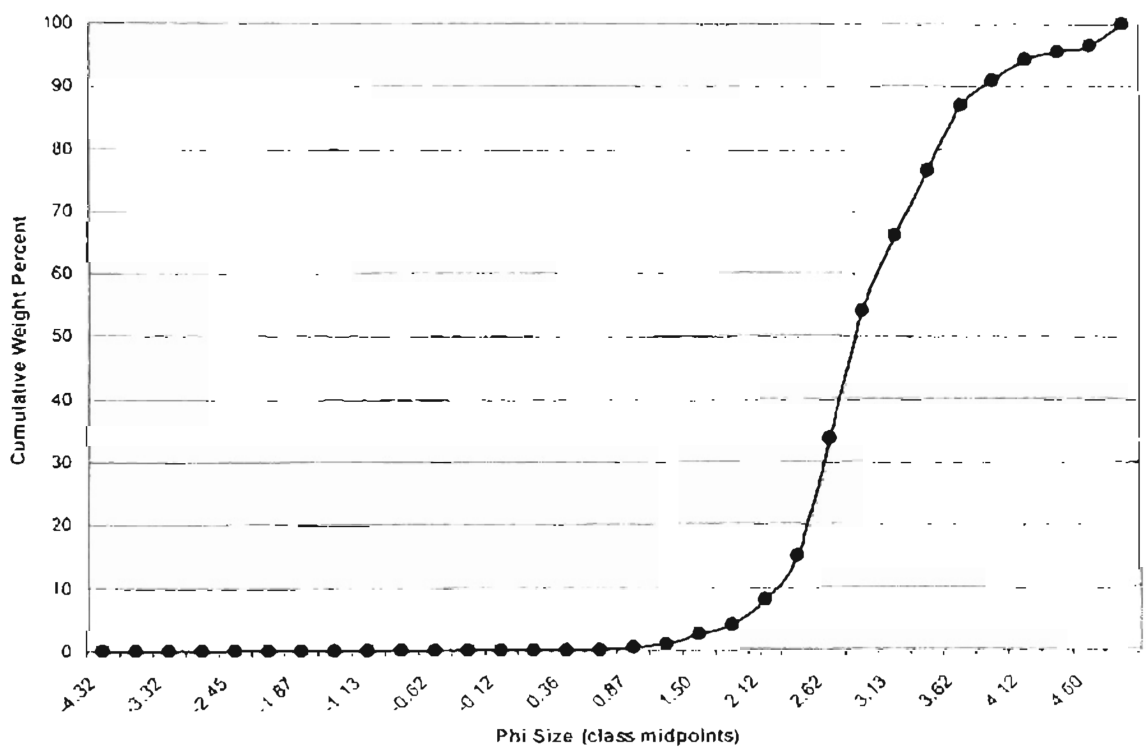


100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Pebbly Road, 5.2 miles north of Little Axe Park entrance

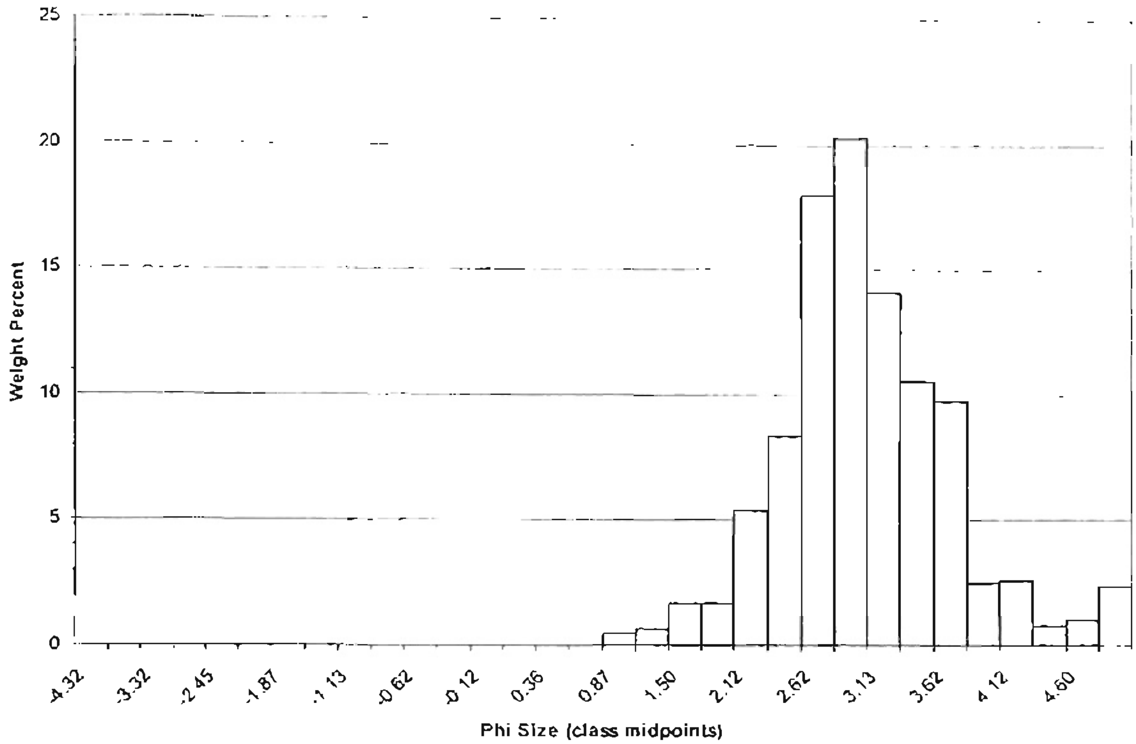
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.37	54.35	0.00	-400.63	0.00
0.50	-3.82	0.00	0.00	0.00	-6.87	47.22	0.00	-324.52	0.00
0.50	-3.32	0.00	0.00	0.00	-6.37	40.60	0.00	-258.71	0.00
0.49	-2.83	0.00	0.00	0.00	-5.88	34.55	0.00	-203.06	0.00
0.38	-2.45	0.00	0.00	0.00	-5.50	30.27	0.00	-166.52	0.00
0.33	-2.12	0.00	0.00	0.00	-5.17	26.77	0.00	-138.51	0.00
0.25	-1.87	0.00	0.00	0.00	-4.92	24.25	0.00	-119.40	0.00
0.37	-1.50	0.00	0.00	0.00	-4.55	20.70	0.00	-94.12	0.00
0.37	-1.13	0.00	0.00	0.00	-4.18	17.43	0.00	-72.80	0.00
0.25	-0.87	0.00	0.00	0.00	-3.92	15.40	0.00	-60.43	0.00
0.25	-0.62	0.00	0.00	0.00	-3.67	13.48	0.00	-49.51	0.00
0.25	-0.37	0.00	0.00	0.00	-3.42	11.68	0.00	-39.90	0.00
0.25	-0.12	0.00	0.00	0.00	-3.17	10.05	0.00	-31.84	0.00
0.24	0.12	0.00	0.00	0.00	-2.93	8.60	0.00	-25.23	0.00
0.25	0.33	0.00	0.00	0.00	-2.69	7.21	0.00	-19.37	0.00
0.25	0.62	0.00	0.00	0.00	-2.43	5.93	0.00	-14.43	0.00
0.25	0.87	0.46	0.46	0.40	-2.18	4.78	2.19	-10.38	-4.78
0.25	1.12	0.58	1.04	0.65	-1.93	3.74	2.17	-7.22	-4.19
0.38	1.50	1.62	2.66	2.43	-1.55	2.41	3.90	-3.74	-6.06
0.38	1.83	1.45	4.11	2.73	-1.17	1.37	1.98	-1.60	-2.32
0.24	2.12	3.94	9.05	8.35	-0.93	0.87	3.42	-0.81	-3.18
0.25	2.37	7.07	15.12	16.74	-0.68	0.47	3.29	-0.32	-2.24
0.25	2.62	18.66	33.78	48.83	-0.43	0.18	3.41	-0.08	-1.46
0.25	2.87	20.39	54.17	58.59	-0.18	0.03	0.64	-0.01	-0.11
0.25	3.13	12.05	66.22	37.67	0.08	0.01	0.07	0.00	0.01
0.25	3.30	10.31	76.53	34.04	0.33	0.11	1.12	0.04	0.37
0.24	3.62	10.37	86.90	37.56	0.57	0.33	3.39	0.19	1.94
0.25	3.87	4.11	91.01	15.90	0.82	0.67	2.75	0.55	2.25
0.25	4.12	3.24	94.25	13.35	1.07	1.14	3.70	1.22	3.96
0.24	4.35	1.16	95.41	5.05	1.31	1.71	1.98	2.23	2.58
0.24	4.60	1.10	96.51	5.06	1.55	2.39	2.63	3.69	4.06
0.20	4.83	3.48	99.99	16.9	1.81	3.27	11.39	5.92	20.60
	sum	**99.99**		**305.13**			**48.02**		**11.43**
		3.00		3.05			**0.69**		**0.34**
		Mode		*Mean*			*StandDev*		*Skewness*


Weight Percent
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

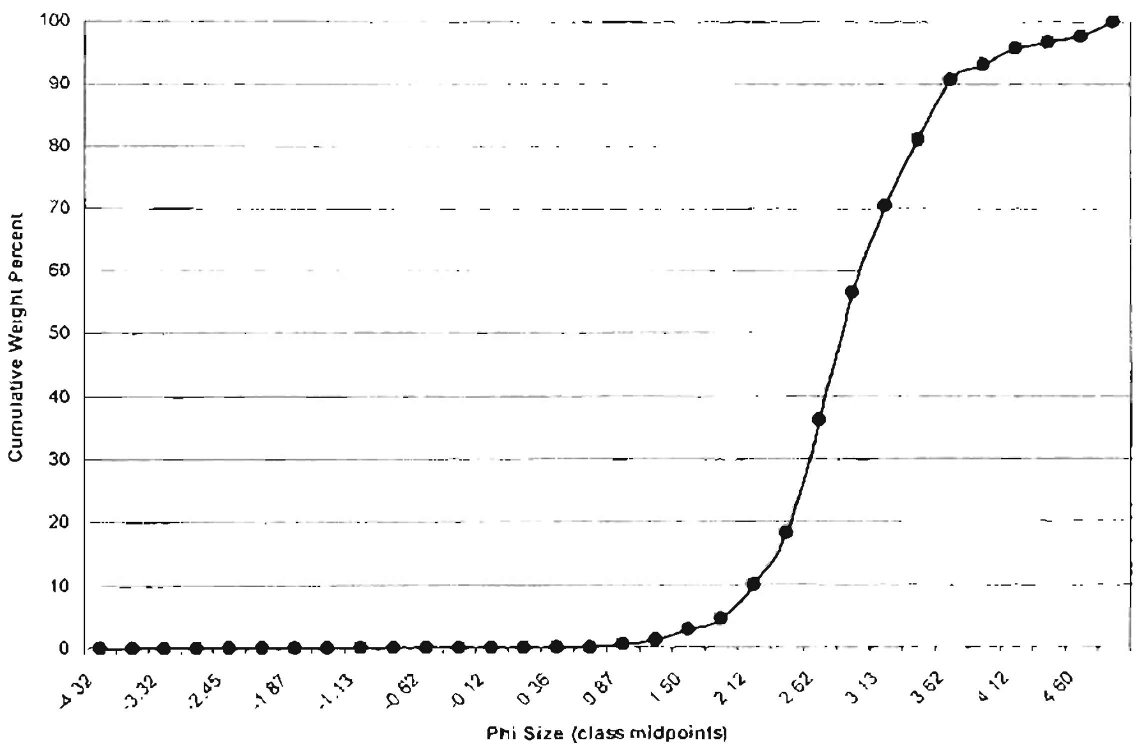

Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Pebbly Road, 5.4 miles north of Little Axe Park entrance

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
nterval	-4.32	0.00	0.00	0.00	-7.30	53.32	0.00	-389.33	0.00
0.50	-3.82	0.00	0.00	0.00	-6.80	46.27	0.00	-314.70	0.00
0.50	-3.32	0.00	0.00	0.00	-6.30	39.71	0.00	-250.28	0.00
0.49	-2.83	0.00	0.00	0.00	-5.81	33.73	0.00	-195.89	0.00
0.38	-2.45	0.00	0.00	0.00	-5.43	29.50	0.00	-160.25	0.00
0.33	-2.12	0.00	0.00	0.00	-5.10	26.05	0.00	-132.96	0.00
0.25	-1.87	0.00	0.00	0.00	-4.85	23.50	0.00	-114.38	0.00
0.37	-1.50	0.00	0.00	0.00	-4.48	20.07	0.00	-89.90	0.00
0.37	-1.13	0.00	0.00	0.00	-4.11	16.85	0.00	-69.20	0.00
0.25	-0.87	0.00	0.00	0.00	-3.85	14.86	0.00	-57.25	0.00
0.25	-0.62	0.00	0.00	0.00	-3.60	12.97	0.00	-46.74	0.00
0.25	-0.37	0.00	0.00	0.00	-3.35	11.20	0.00	-37.50	0.00
0.25	-0.12	0.00	0.00	0.00	-3.10	9.61	0.00	-29.77	0.00
0.24	0.12	0.00	0.00	0.00	-2.86	8.20	0.00	-23.46	0.00
0.25	0.36	0.00	0.00	0.00	-2.62	6.84	0.00	-17.90	0.00
0.25	0.62	0.00	0.00	0.00	-2.36	5.59	0.00	-13.22	0.00
0.25	0.87	0.45	0.45	0.39	-2.11	4.46	2.01	-9.41	-4.24
0.25	1.12	0.64	1.09	0.72	-1.86	3.47	2.22	-6.43	-4.14
0.38	1.50	1.68	2.77	2.52	-1.48	2.20	3.69	-3.26	-5.47
0.38	1.88	1.68	4.45	3.16	-1.10	1.21	2.03	-1.33	-2.23
0.24	2.12	5.39	9.84	11.42	-0.86	0.74	4.00	-0.64	-3.44
0.25	2.37	8.31	18.15	19.68	-0.61	0.37	3.11	-0.23	-1.90
0.25	2.62	17.96	36.11	47.10	-0.36	0.13	2.30	-0.05	-0.82
0.25	2.87	20.29	56.40	58.30	-0.11	0.01	0.23	0.00	-0.02
0.25	3.13	14.05	70.45	43.97	0.15	0.02	0.30	0.00	0.04
0.25	3.38	10.54	80.99	35.61	0.40	0.16	1.68	0.06	0.67
0.24	3.62	9.75	90.74	35.31	0.64	0.41	4.01	0.26	2.58
0.25	3.87	2.47	93.21	9.56	0.89	0.79	1.95	0.70	1.73
0.25	4.12	2.62	95.83	10.79	1.14	1.30	3.40	1.48	3.87
0.24	4.36	0.79	96.62	3.44	1.38	1.89	1.50	2.60	2.06
0.24	4.60	0.99	97.61	4.55	1.62	2.61	2.59	4.22	4.18
0.26	4.86	2.38	99.99	11.56	1.88	3.53	6.40	6.63	15.79
	sum	99.99		298.02			43.41		8.65
		3.00 Mode		2.98 Mean			0.66 StandDev		0.30 Skewness



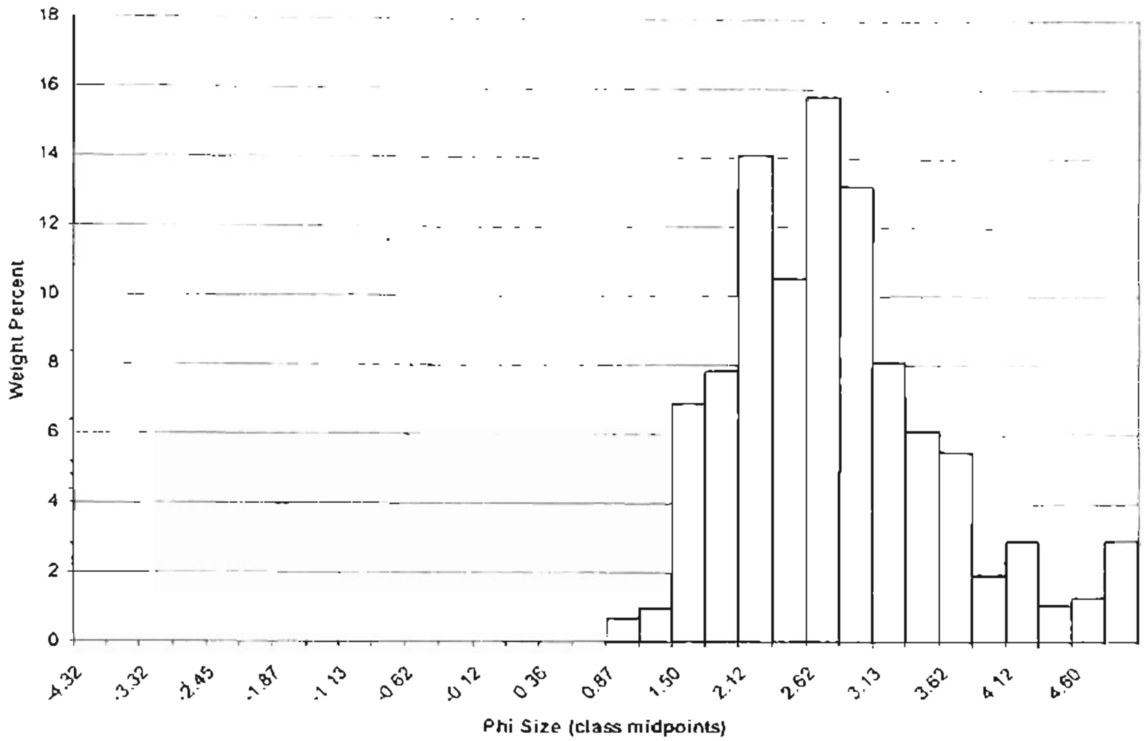
25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)



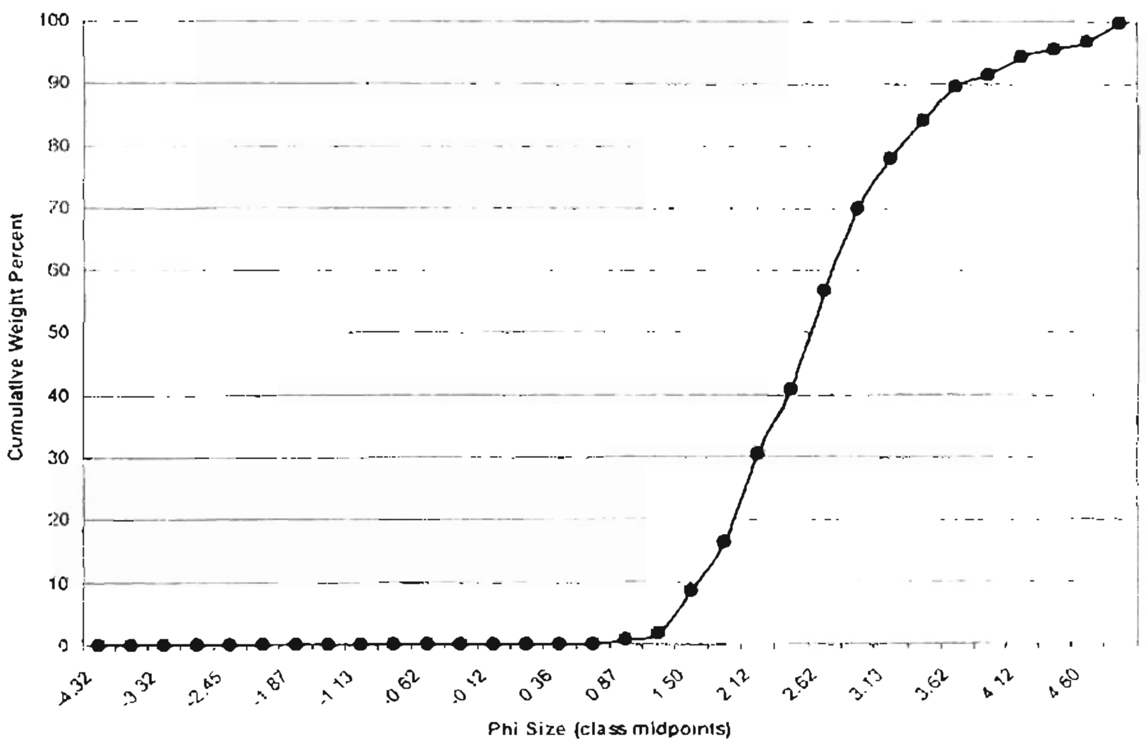
100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Pebbly Road, 6.0 miles north of Little Axe Park entrance

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.03	49.45	0.00	-347.71	0.00
0.50	-3.82	0.00	0.00	0.00	-6.53	42.67	0.00	-278.69	0.00
0.50	-3.32	0.00	0.00	0.00	-6.03	36.38	0.00	-219.47	0.00
0.49	-2.83	0.00	0.00	0.00	-5.54	30.67	0.00	-169.82	0.00
0.38	-2.45	0.00	0.00	0.00	-5.16	26.64	0.00	-137.52	0.00
0.33	-2.12	0.00	0.00	0.00	-4.83	23.37	0.00	-112.96	0.00
0.25	-1.87	0.00	0.00	0.00	-4.58	21.02	0.00	-96.34	0.00
0.37	-1.50	0.00	0.00	0.00	-4.21	17.72	0.00	-74.60	0.00
0.37	-1.13	0.00	0.00	0.00	-3.84	14.71	0.00	-56.42	0.00
0.25	-0.87	0.00	0.00	0.00	-3.58	12.85	0.00	-46.05	0.00
0.25	-0.62	0.00	0.00	0.00	-3.33	11.10	0.00	-37.00	0.00
0.25	-0.37	0.00	0.00	0.00	-3.08	9.47	0.00	-29.14	0.00
0.25	-0.12	0.00	0.00	0.00	-2.83	8.01	0.00	-22.65	0.00
0.24	0.12	0.00	0.00	0.00	-2.59	6.72	0.00	-17.43	0.00
0.25	0.36	0.00	0.00	0.00	-2.35	5.50	0.00	-12.91	0.00
0.25	0.62	0.00	0.00	0.00	-2.09	4.39	0.00	-9.19	0.00
0.25	0.87	0.67	0.67	0.58	-1.84	3.39	2.27	-6.24	-4.18
0.25	1.12	0.97	1.64	1.08	-1.59	2.54	2.46	-4.04	-3.92
0.38	1.50	6.90	8.54	10.34	-1.21	1.47	10.14	-1.78	-12.29
0.38	1.88	7.81	16.35	14.69	-0.83	0.69	5.37	-0.57	-4.46
0.24	2.12	14.07	30.42	29.81	-0.59	0.35	4.92	-0.21	-2.91
0.25	2.37	10.52	40.94	24.91	-0.34	0.12	1.23	-0.04	-0.42
0.25	2.62	15.77	56.71	41.36	-0.09	0.01	0.12	0.00	-0.01
0.25	2.87	13.21	69.92	37.96	0.16	0.03	0.35	0.00	0.06
0.25	3.13	8.07	77.99	25.22	0.42	0.17	1.40	0.07	0.58
0.25	3.38	6.09	84.08	20.58	0.67	0.45	2.73	0.30	1.82
0.24	3.62	5.50	89.58	19.92	0.91	0.83	4.57	0.76	4.17
0.25	3.87	1.90	91.48	7.35	1.16	1.34	2.55	1.55	2.95
0.25	4.12	2.93	94.41	12.07	1.41	1.99	5.82	2.80	8.19
0.24	4.36	1.05	95.46	4.57	1.65	2.71	2.84	4.46	4.68
0.24	4.60	1.29	96.75	5.93	1.89	3.56	4.59	6.71	8.65
0.20	4.80	2.93	99.68	14.24	2.15	4.62	13.53	9.92	29.08
	sum	**99.68**		**270.60**			**64.88**		**32.00**
		2.75		**2.71**			**0.81**		**0.61**
		Mode		***Mean***			***StandDev***		***Skewness***



Weight Percent
18
16
14
12
10
8
6
4
2
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

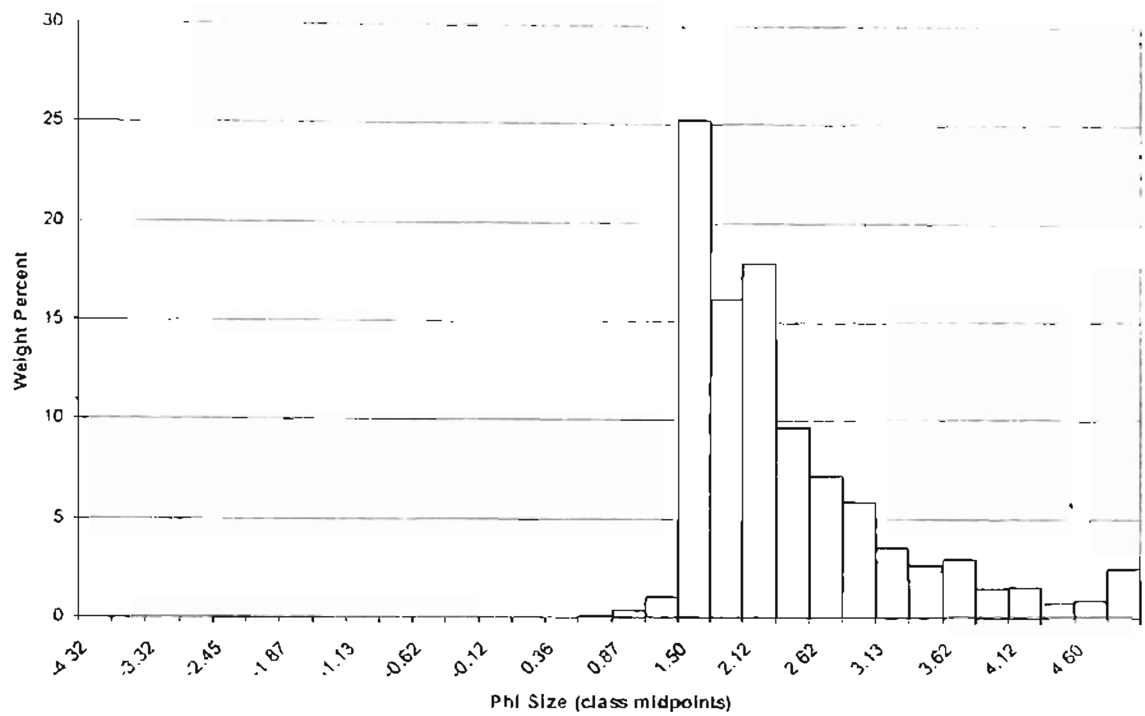


Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

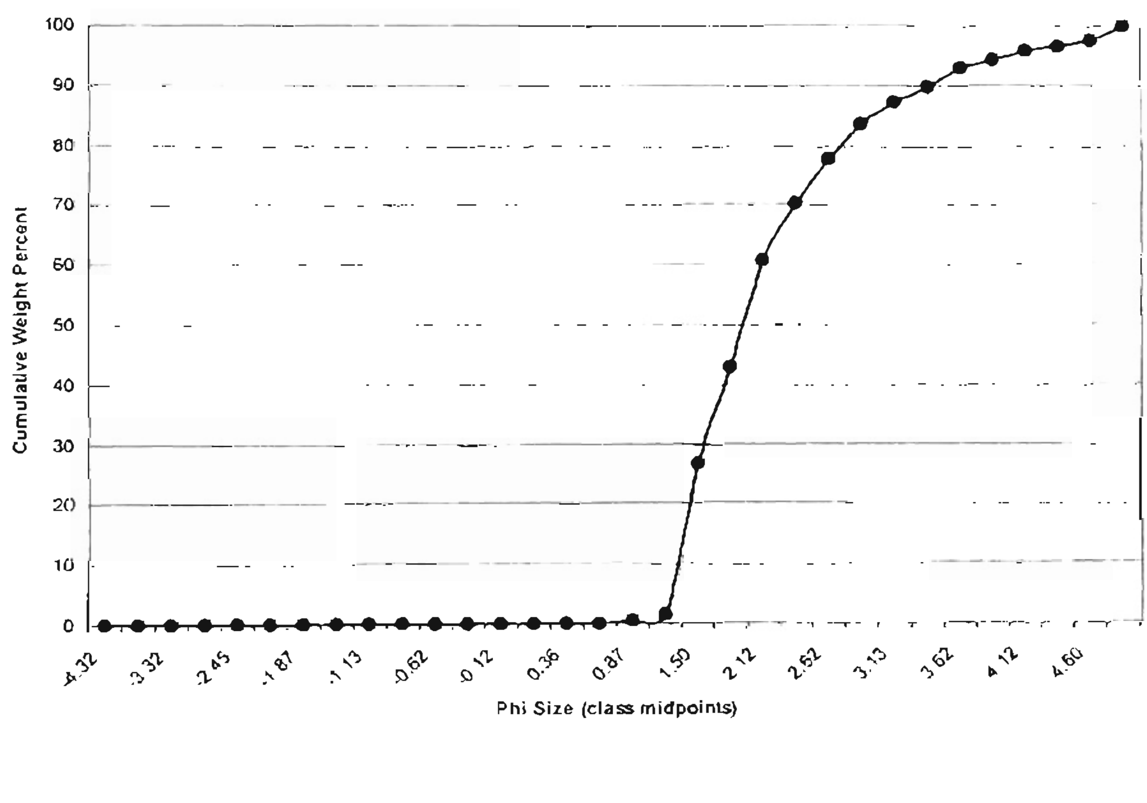
180th NE Street, 0.2 miles north of Hwy 9

	Phi Midpoint	Weight %	Cumulative weight %	Product	Deviation	Deviation Squared	Product	Deviation Cubed	Product	Deviation quadrupled	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$	$(m-x)^4$	$f(m-x)^4$
Interval	-4.32	0.00	0.03	0.00	-6.61	43.72	0.00	-289.06	0.00	19[illegible].23	0.03
0.50	-3.82	0.00	0.03	0.00	-6.11	37.36	0.00	-228.32	0.00	1395.15	0.00
0.50	-3.32	0.00	0.03	0.00	-5.61	31.49	0.00	-176.71	0.00	991.86	0.00
0.49	-2.83	0.00	0.03	0.00	-5.12	26.19	0.00	-134.04	0.00	685.95	0.00
0.38	-2.[illegible]	0.00	0.03	0.00	[illegible]	23.[illegible]	0.00	[illegible]	0.00	[illegible]	0.00
0.33	-2.[illegible]2	0.00	0.03	0.00	-4.41	19.48	0.00	-86.00	0.00	379.53	0.00
0.28	-1.87	0.00	0.03	0.00	-4.16	17.34	0.00	-72.21	0.00	300.70	0.00
0.27	-1.60	0.00	0.03	0.00	-3.79	14.36	0.00	-54.43	0.00	206.26	0.00
0.37	-1.[illegible]3	0.00	0.03	0.00	-3.42	11.68	0.00	-39.94	0.00	136.08	0.00
0.25	-0.87	0.00	0.03	0.00	-3.16	10.01	0.00	-31.68	0.00	100.25	0.00
0.25	-0.62	0.00	0.03	0.00	-2.91	8.49	0.00	-24.70	0.00	7[illegible].91	0.00
0.25	-0.37	0.00	0.03	0.00	-2.66	7.06	0.00	-18.76	0.00	49.86	0.00
0.25	-0.[illegible]	0.00	0.03	0.00	-2.[illegible]	5.8[illegible]	0.00	-13.99	0.00	33.[illegible]	0.00
0.24	0.12	0.00	0.03	0.00	-2.17	4.72	0.00	-10.26	0.00	22.29	0.00
0.25	0.36	0.00	0.03	0.00	-1.93	3.71	0.00	-7.14	0.00	13.75	0.00
0.25	0.62	0.07	0.07	0.04	-1.67	2.80	0.20	-4.69	-0.33	7.86	0.55
0.25	0.87	0.34	0.41	0.30	-1.42	2.02	0.70	-2.87	-1.00	4.08	1.42
0.25	1.12	1.04	1.45	[illegible]	-1.17	1.35	1.43	-1.61	-1.68	1.89	1.97
0.33	1.50	25.25	26.72	37.82	-0.79	0.63	5.84	-0.50	-12.55	0.39	9.94
0.38	1.88	16.12	42.81	30.32	-0.41	0.17	2.70	-0.07	-1.11	0.03	0.45
0.24	2.12	17.91	60.78	38.0[illegible]	-0.17	0.03	0.53	-0.01	-0.09	0.00	0.02
0.25	2.37	9.66	70.44	22.88	0.08	0.01	0.06	0.00	0.00	0.00	0.00
0.25	2.62	7.24	77.68	18.99	0.33	0.11	0.80	0.04	0.27	0.01	0.09
0.25	2.87	5.87	83.55	16.87	0.58	0.34	2.00	0.20	1.17	0.12	0.68
0.25	3.13	3.55	87.11	11.22	0.84	0.70	2.51	0.58	2.10	0.49	[illegible]
0.26	3.38	2.61	89.72	9.06	1.09	1.19	3.18	1.29	3.46	1.41	3.77
0.24	3.62	3.0[illegible]	92.82	10.86	1.33	1.77	5.32	2.36	7.08	3.14	9.43
0.25	3.87	1.47	94.29	5.69	1.58	2.49	3.66	3.93	5.78	6.21	9.13
0.25	4.12	1.53	95.82	6.30	1.83	3.34	5.12	6.12	9.36	11.19	17.12
0.24	4.36	0.72	96.54	3.[illegible]	2.07	4.27	3.07	8.82	6.35	18.22	13.11
0.24	4.60	0.91	97.45	4.[illegible]	2.31	5.32	4.84	12.28	11.16	28.37	25.73
0.24	4.84	2.47	[illegible]	12.3[illegible]	2.57	6.60	[illegible]	16.96	12.06	43.6[illegible]	[illegible]
	Sum	99.91		233.19			18.74		73.50		305.33
		1.74		2.35			4.33		1.21		4.34
		Mode		Mean			StandDev		Skewness		Kurtosis

279



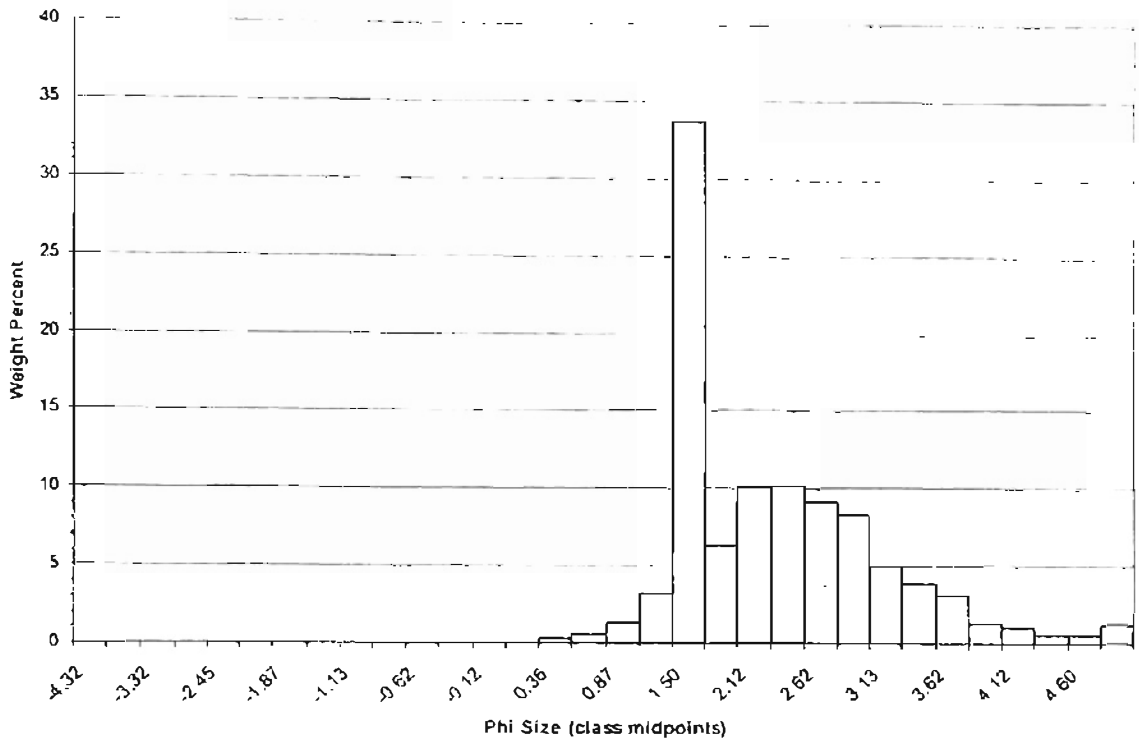
Weight Percent
30
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

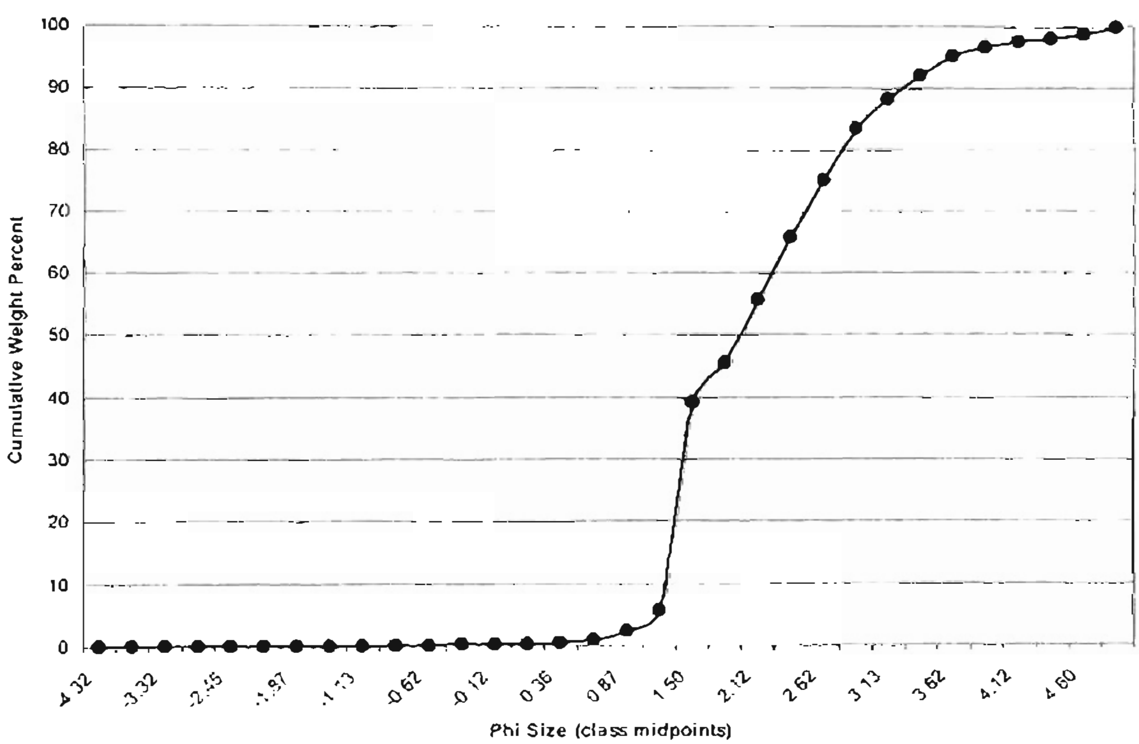


Cumulative Weight Percent
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

180th NE Street, 0.9 miles north of Hwy 9

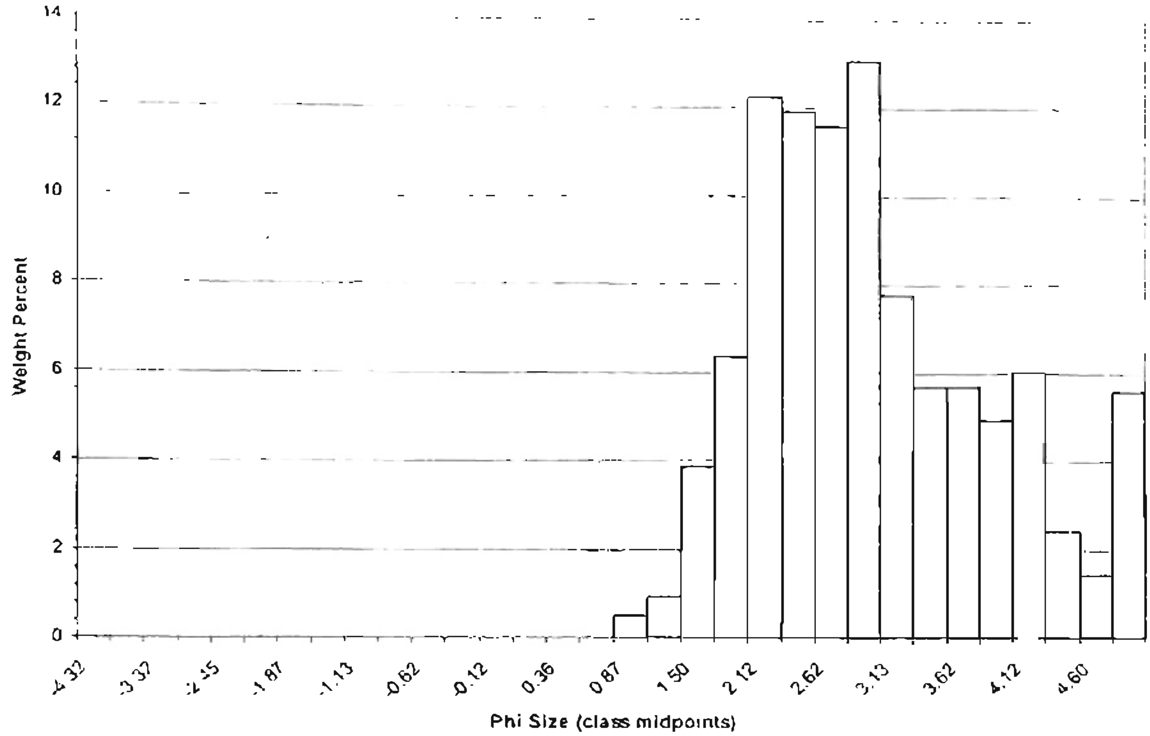
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.53	42.67	0.00	-278.69	0.00
0.50	-3.82	0.00	0.00	0.00	-6.03	36.38	0.00	-219.47	0.00
0.50	-3.32	0.00	0.00	0.00	-5.53	30.60	0.00	-169.29	0.00
0.49	-2.83	0.00	0.00	0.00	-5.04	25.38	0.00	-127.85	0.00
0.38	-2.45	0.00	0.00	0.00	-4.66	21.73	0.00	-101.30	0.00
0.33	-2.12	0.00	0.00	0.00	-4.33	18.78	0.00	-81.41	0.00
0.25	-1.87	0.00	0.00	0.00	-4.08	16.68	0.00	-68.13	0.00
0.37	-1.50	0.00	0.00	0.00	-3.71	13.76	0.00	-51.05	0.00
0.37	-1.13	0.03	0.03	-0.03	-3.34	11.13	0.33	-37.11	-1.11
0.25	-0.87	0.03	0.06	-0.03	-3.08	9.51	0.29	-29.34	-0.88
0.25	-0.62	0.03	0.09	-0.02	-2.83	8.02	0.24	-22.72	-0.68
0.25	-0.37	0.06	0.15	-0.02	-2.58	6.64	0.40	-17.12	-1.03
0.25	-0.12	0.03	0.18	0.00	-2.33	5.43	0.16	-12.64	-0.38
0.24	0.12	0.06	0.24	0.01	-2.09	4.38	0.26	-9.17	-0.55
0.25	0.36	0.24	0.48	0.09	-1.85	3.41	0.82	-6.29	-1.51
0.25	0.62	0.56	1.04	0.34	-1.59	2.54	1.42	-4.05	-2.27
0.25	0.87	1.30	2.34	1.13	-1.34	1.80	2.34	-2.41	-3.14
0.25	1.12	3.25	5.59	3.63	-1.09	1.19	3.88	-1.30	-4.24
0.38	1.50	33.70	39.29	50.48	-0.71	0.51	17.09	-0.36	-12.17
0.38	1.88	6.36	45.65	11.96	-0.33	0.11	0.69	-0.04	-0.23
0.24	2.12	10.11	55.76	21.42	-0.09	0.01	0.08	0.00	-0.01
0.25	2.37	10.17	65.93	24.08	0.16	0.02	0.25	0.00	0.04
0.25	2.62	9.16	75.09	24.02	0.41	0.17	1.56	0.07	0.64
0.25	2.87	8.28	83.37	23.79	0.66	0.44	3.64	0.29	2.42
0.25	3.13	4.97	88.34	15.54	0.92	0.84	4.17	0.77	3.82
0.25	3.38	3.87	92.21	13.08	1.17	1.37	5.29	1.60	6.18
0.24	3.62	3.10	95.31	11.23	1.41	1.99	6.18	2.81	8.72
0.25	3.87	1.30	96.61	5.03	1.66	2.75	3.58	4.56	5.93
0.25	4.12	1.01	97.62	4.16	1.91	3.64	3.68	6.96	7.03
0.24	4.36	0.53	98.15	2.31	2.15	4.60	2.44	9.88	5.24
0.24	4.60	0.59	98.74	2.71	2.39	5.69	3.36	13.58	8.01
0.26	4.86	1.27	100.01	6.17	2.65	7.02	8.91	18.59	23.61
	sum	100.01		221.07			71.07		43.43
		2.50 Mode		2.21 Mean			0.84 StandDev		0.72 Skewness


Weight Percent
Phi Size (class midpoints)
40
35
30
25
20
15
10
5
0
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

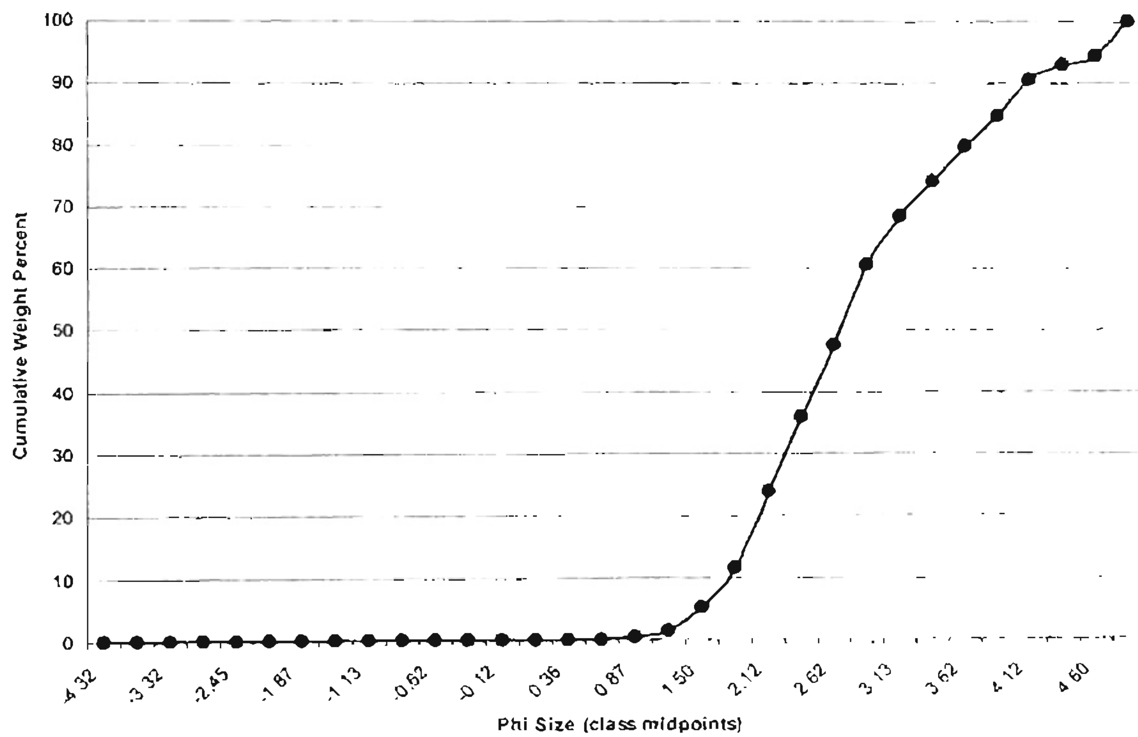

Cumulative Weight Percent
Phi Size (class midpoints)
100
90
80
70
60
50
40
30
20
10
0
-4.32
-3.32
-2.45
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

180^{th} NE Street, 1.3 miles north of Hwy 9

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	4.32	0.00	0.00	0.00	7.25	52.60	0.00	381.39	0.00
0.50	-3.82	0.00	0.00	0.00	-6.75	45.59	0.00	-307.81	0.00
0.50	-3.32	0.00	0.00	0.00	-6.25	39.09	0.00	-244.37	0.00
0.49	-2.83	0.00	0.00	0.00	-5.76	33.15	0.00	-190.87	0.00
0.38	-2.45	0.00	0.00	0.00	-5.38	28.96	0.00	-155.86	0.00
0.33	-2.12	0.00	0.00	0.00	-5.05	25.54	0.00	-129.09	0.00
0.25	-1.87	0.00	0.00	0.00	-4.80	23.08	0.00	-110.88	0.00
0.37	-1.50	0.00	0.00	0.00	-4.43	19.62	0.00	-86.92	0.00
0.37	-1.13	0.00	0.00	0.00	-4.06	16.45	0.00	-66.70	0.00
0.25	-0.87	0.00	0.00	0.00	-3.80	14.47	0.00	-55.06	0.00
0.25	-0.62	0.00	0.00	0.00	-3.55	12.62	0.00	-44.82	0.00
0.25	-0.37	0.00	0.00	0.00	-3.30	10.87	0.00	-35.85	0.00
0.25	-0.12	0.00	0.00	0.00	-3.05	9.30	0.00	-28.36	0.00
0.24	0.12	0.00	0.00	0.00	-2.81	7.91	0.00	-22.25	0.00
0.25	0.36	0.00	0.00	0.00	-2.57	6.58	0.00	-16.89	0.00
0.25	0.62	0.00	0.00	0.00	-2.31	5.36	0.00	-12.40	0.00
0.25	0.87	0.49	0.49	0.43	-2.06	4.25	2.08	-8.76	-4.29
0.25	1.12	0.93	1.42	1.04	-1.81	3.29	3.06	-5.96	-5.54
0.38	1.50	3.88	5.30	5.81	-1.43	2.05	7.96	-2.94	-11.40
0.38	1.83	6.35	11.65	11.94	-1.05	1.10	6.99	-1.16	-7.34
0.24	2.12	12.25	23.90	25.98	-0.81	0.66	8.06	-0.53	-6.54
0.25	2.37	11.93	35.83	28.25	-0.56	0.32	3.77	-0.18	-2.12
0.25	2.62	11.60	47.43	30.42	-0.31	0.09	1.10	-0.03	-0.34
0.25	2.07	13.07	60.50	37.55	-0.06	0.00	0.04	0.00	0.00
0.25	3.13	7.77	68.27	24.29	0.20	0.04	0.30	0.01	0.06
0.25	3.38	5.69	73.96	19.23	0.45	0.20	1.15	0.09	0.51
0.24	3.62	5.69	79.65	20.61	0.69	0.48	2.72	0.33	1.88
0.25	3.87	4.92	84.57	19.03	0.94	0.88	4.33	0.83	4.07
0.25	4.12	6.02	90.59	24.80	1.19	1.41	8.51	1.68	10.12
0.24	4.36	2.41	93.00	10.56	1.43	2.03	4.90	2.90	6.99
0.24	4.60	1.42	94.42	6.53	1.67	2.78	3.94	4.62	6.56
0.26	4.86	5.58	100.00	27.11	1.93	3.72	20.76	7.18	40.05
	sum	100.00		293.49			79.67		32.60
		3.00		2.93			0.89		0.46
		mode		Mean			StandDev		Skewness



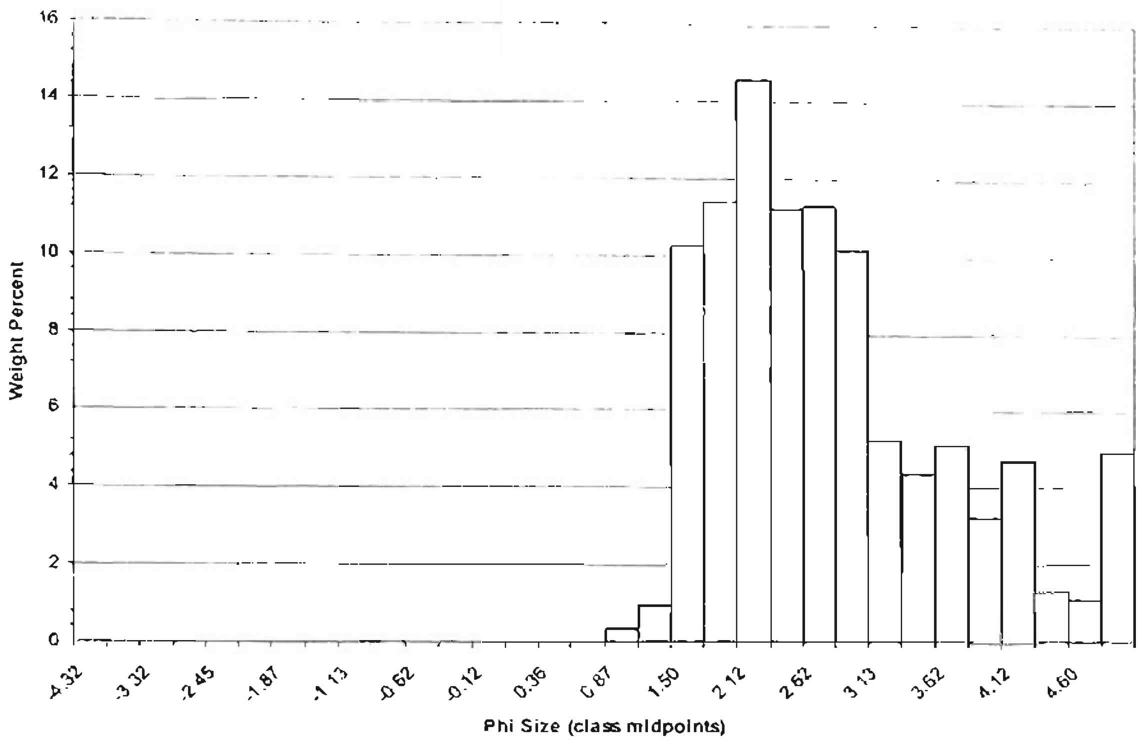
Weight Percent
Phi Size (class midpoints)

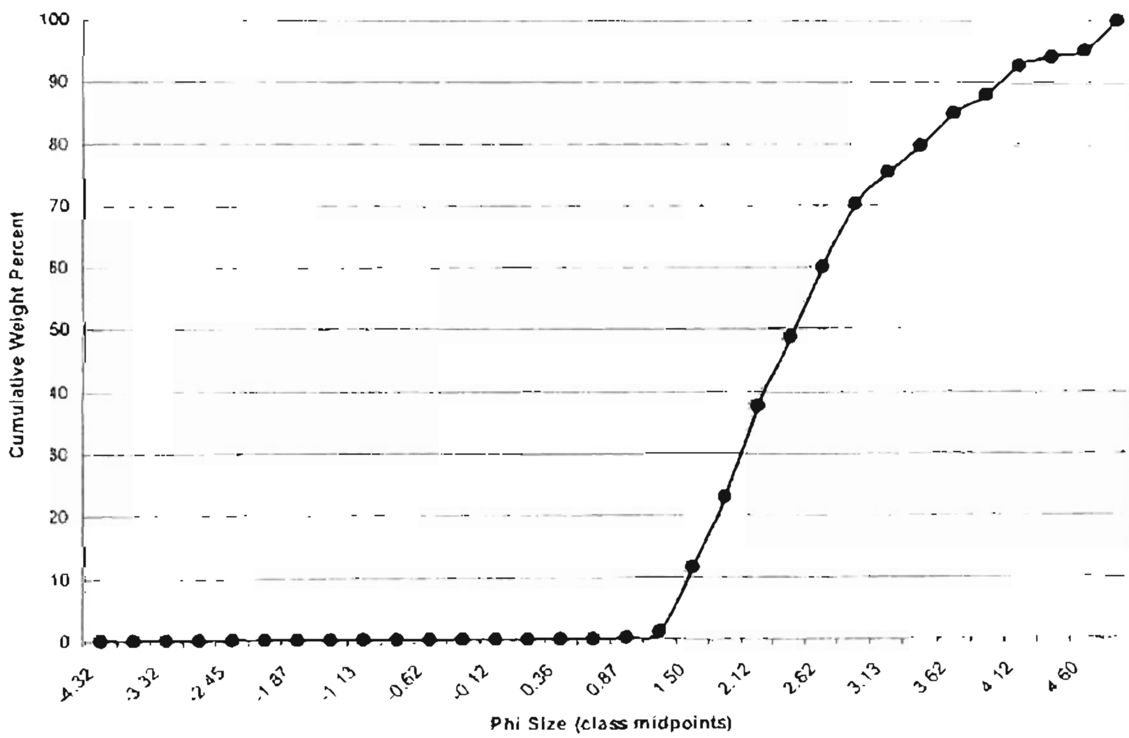


Cumulative Weight Percent
Phi Size (class midpoints)

180th NE Street, 1.4 miles north of Hwy 9

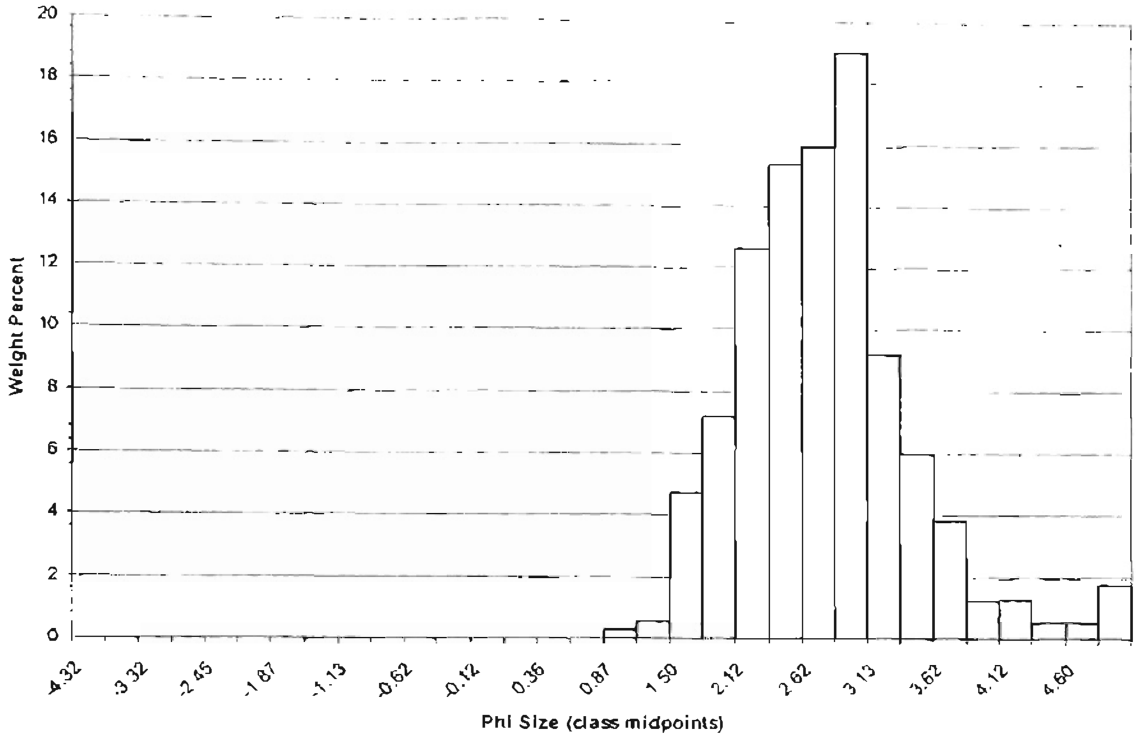
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-7.02	49.31	0.00	-346.23	0.00
0.50	-3.82	0.00	0.00	0.00	-6.52	42.54	0.00	-277.41	0.00
0.50	-3.32	0.00	0.00	0.00	-6.02	36.26	0.00	-218.38	0.00
0.49	-2.83	0.00	0.00	0.00	-5.53	30.58	0.00	-168.90	0.00
0.38	-2.45	0.00	0.00	0.00	-5.15	26.54	0.00	-136.72	0.00
0.33	-2.12	0.00	0.00	0.00	-4.82	23.27	0.00	-112.26	0.00
0.25	-1.87	0.00	0.00	0.00	-4.57	20.92	0.00	-95.71	0.00
0.37	-1.50	0.00	0.00	0.00	-4.20	17.64	0.00	-74.07	0.00
0.37	-1.13	0.00	0.00	0.00	-3.83	14.63	0.00	-55.98	0.00
0.25	-0.87	0.00	0.00	0.00	-3.57	12.78	0.00	-45.66	0.00
0.25	-0.62	0.00	0.00	0.00	-3.32	11.04	0.00	-36.66	0.00
0.25	-0.37	0.00	0.00	0.00	-3.07	9.41	0.00	-28.86	0.00
0.25	-0.12	0.00	0.00	0.00	-2.82	7.95	0.00	-22.41	0.00
0.24	0.12	0.00	0.00	0.00	-2.58	6.67	0.00	-17.23	0.00
0.25	0.36	0.00	0.00	0.00	-2.34	5.46	0.00	-12.74	0.00
0.25	0.62	0.00	0.00	0.00	-2.08	4.34	0.00	-9.06	0.00
0.25	0.87	0.35	0.35	0.30	-1.83	3.35	1.17	-6.14	-2.15
0.25	1.12	0.93	1.28	1.04	-1.58	2.51	2.33	-3.97	-3.69
0.38	1.50	10.24	11.52	15.34	-1.20	1.45	14.80	-1.74	-17.79
0.38	1.88	11.39	22.91	21.42	-0.82	0.67	7.65	-0.55	-6.27
0.24	2.12	14.58	37.49	30.89	-0.58	0.34	4.92	-0.20	-2.86
0.25	2.37	11.20	48.69	26.52	-0.33	0.11	1.23	-0.04	-0.41
0.25	2.62	11.26	59.95	29.53	-0.08	0.01	0.07	0.00	-0.01
0.25	2.87	10.15	70.10	29.16	0.17	0.03	0.30	0.01	0.05
0.25	3.13	5.23	75.33	16.35	0.43	0.18	0.95	0.08	0.40
0.25	3.38	4.34	79.67	14.66	0.68	0.46	2.00	0.31	1.36
0.24	3.62	5.11	84.78	18.51	0.92	0.85	4.34	0.78	4.00
0.25	3.87	3.22	88.00	12.46	1.17	1.37	4.40	1.60	5.14
0.25	4.12	4.69	92.69	19.32	1.42	2.01	9.44	2.86	13.40
0.24	4.35	1.31	94.00	5.71	1.66	2.74	3.59	4.54	5.95
0.24	4.60	1.08	95.08	4.96	1.90	3.59	3.88	6.81	7.36
0.26	4.86	4.91	99.99	23.86	2.16	4.66	22.89	10.06	49.41
	sum	99.99		270.03			83.97		53.90
		2.24		2.70			0.92		0.70
		Mode		Mean			StandDev		Skewness

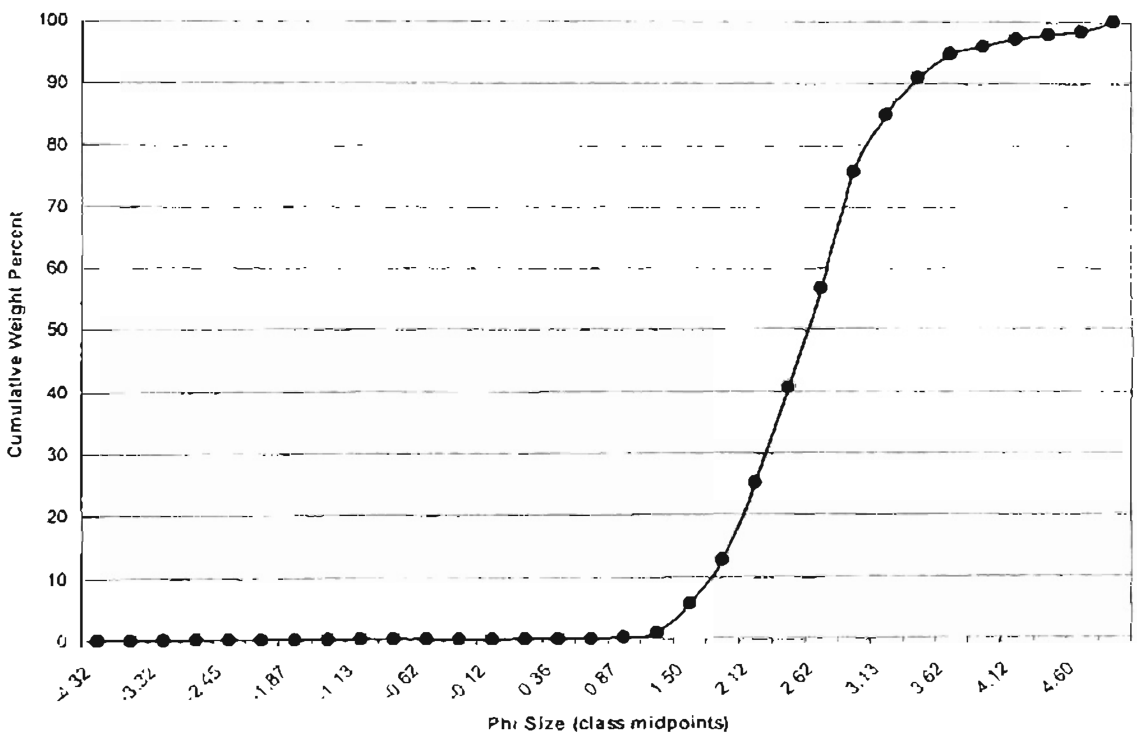

16
14
12
10
8
6
4
2
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)


100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

180th NE Street. 2 7 miles north of Hwy 9

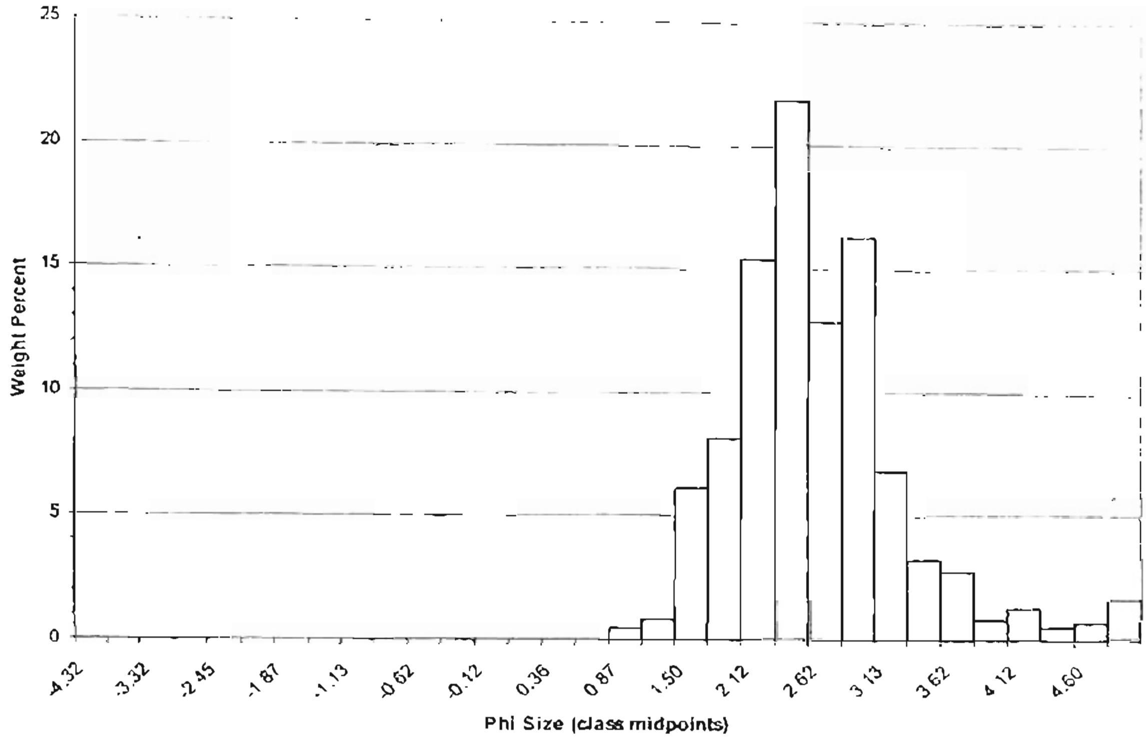
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
Interva	-4.32	0.00	0.00	0.00	-6.99	48.83	0.00	-341.81	0.00
0.50	-3.82	0.00	0.00	0.00	-6.49	42.15	0.00	-273.60	0.00
0.50	-3.32	0.00	0.00	0.00	-5.99	35.90	0.00	-215.13	0.00
0.49	-2.83	0.00	0.00	0.00	-5.50	30.22	0.00	-166.16	0.00
0.30	-2.45	0.00	0.00	0.00	-5.12	26.20	0.00	-134.05	0.00
0.33	-2.12	0.00	0.00	0.00	-4.79	22.93	0.00	-110.18	0.00
0.25	-1.87	0.00	0.00	0.00	-4.54	20.65	0.00	-93.84	0.00
0.37	-1.50	0.00	0.00	0.00	-4.17	17.39	0.00	-72.50	0.00
0.37	-1.13	0.00	0.00	0.00	-3.80	14.41	0.00	-54.68	0.00
0.25	-0.87	0.00	0.00	0.00	-3.54	12.53	0.00	-44.52	0.00
0.25	-0.62	0.00	0.00	0.00	-3.29	10.84	0.00	-35.68	0.00
0.25	-0.37	0.00	0.00	0.00	-3.04	9.22	0.00	-28.02	0.00
0.25	-0.12	0.00	0.00	0.00	-2.79	7.73	0.00	-21.70	0.00
0.24	0.12	0.00	0.00	0.00	-2.55	6.52	0.00	-16.64	0.00
0.25	0.36	0.00	0.00	0.00	-2.31	5.32	0.00	12.26	0.00
0.25	0.62	0.00	0.00	0.00	-2.05	4.22	0.00	-8.67	0.00
0.25	0.87	0.27	0.27	0.23	-1.80	3.25	0.88	-5.85	-1.58
0.25	1.12	0.58	0.85	0.65	-1.55	2.41	1.40	-3.74	-2.17
0.38	1.50	4.72	5.57	7.07	-1.17	1.37	6.49	-1.61	-7.60
0.38	1.88	7.17	12.74	13.48	-0.79	0.62	4.47	-0.49	-3.53
0.24	2.12	12.64	25.38	26.78	-0.55	0.30	3.84	-0.17	-2.12
0.25	2.37	15.35	40.73	36.35	-0.30	0.09	1.40	-0.03	-0.42
0.25	2.62	15.93	56.66	41.77	-0.05	0.00	0.04	0.00	0.00
0.25	2.87	18.99	75.65	54.56	0.20	0.04	0.78	0.01	0.16
0.25	3.13	9.24	84.89	28.86	0.46	0.21	1.92	0.09	0.87
0.25	3.38	5.01	90.90	20.31	0.71	0.50	3.02	0.36	2.14
0.24	3.62	3.94	94.74	13.91	0.95	0.91	3.48	0.86	3.31
0.25	3.87	1.22	95.96	4.72	1.20	1.44	1.75	1.72	2.10
0.25	4.12	1.26	97.22	5.19	1.45	2.10	2.65	3.04	3.83
0.24	4.36	0.54	97.76	2.35	1.69	2.84	1.53	4.79	2.59
0.24	4.60	0.51	98.27	2.34	1.93	3.71	1.89	7.14	3.64
0.26	4.86	1.73	100.00	8.41	2.19	4.79	9.29	10.49	18.14
	sum	100.00		267.02			43.82		19.38
		3.00		2.67			0.66		0.67
		Mode		Mean			StandDev		Skewness


Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

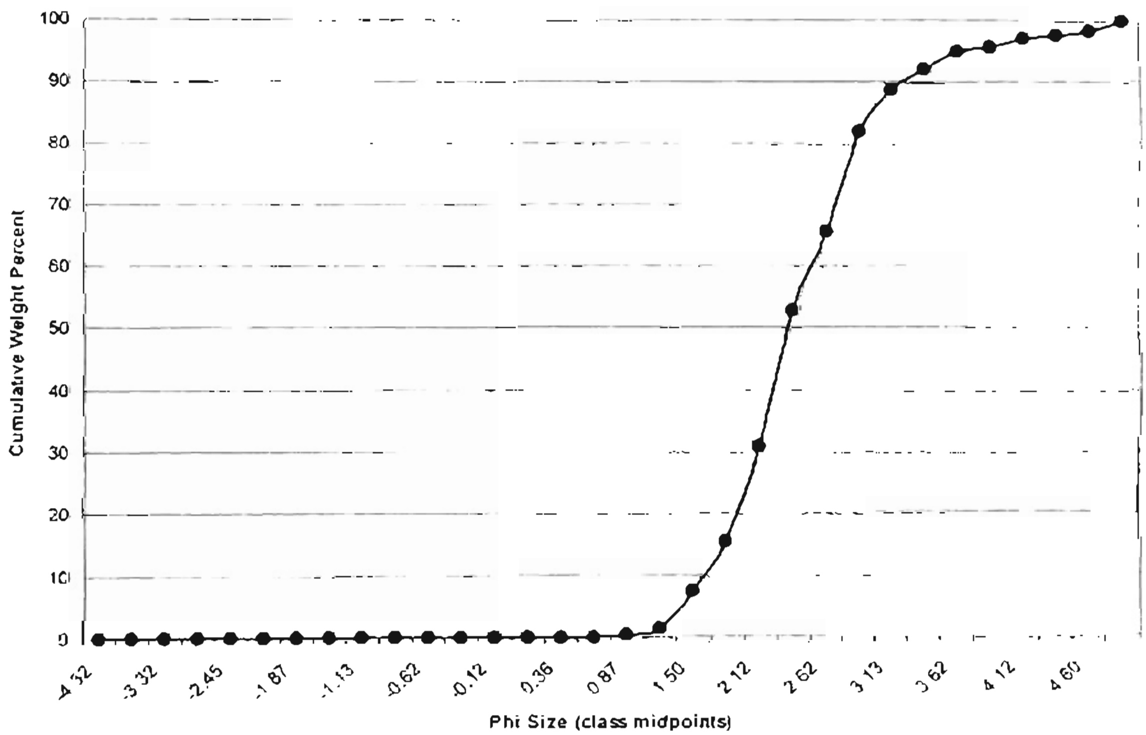

Cumulative Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

Harra-Newalla Road, 0.7 miles north of Hwy 9

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	-4.32	0.00	0.00	0.00	-6.38	47.36	0.00	-325.93	0.00
0.50	-3.82	0.00	0.00	0.00	-6.38	40.73	0.00	-259.93	0.00
0.50	-3.32	0.00	0.00	0.00	-5.88	34.60	0.00	-203.50	0.00
0.49	-2.83	0.00	0.00	0.00	-5.39	29.03	0.00	-156.39	0.00
0.38	-2.45	0.00	0.00	0.00	-5.01	25.12	0.00	-125.88	0.00
0.33	-2.12	0.00	0.00	0.00	-4.68	21.94	0.00	-102.76	0.00
0.25	-1.87	0.00	0.00	0.00	-4.43	19.66	0.00	-87.19	0.00
0.37	-1.50	0.00	0.00	0.00	-4.06	16.48	0.00	-66.91	0.00
0.37	-1.13	0.00	0.00	0.00	-3.69	13.58	0.00	-50.06	0.00
0.25	-0.87	0.00	0.00	0.00	-3.43	11.79	0.00	-40.50	0.00
0.25	-0.62	0.00	0.00	0.00	-3.18	10.13	0.00	-32.22	0.00
0.25	-0.37	0.00	0.00	0.00	-2.93	8.57	0.00	-25.08	0.00
0.25	-0.12	0.00	0.00	0.00	-2.68	7.18	0.00	-19.24	0.00
0.24	0.12	0.00	0.00	0.00	-2.44	5.97	0.00	-14.58	0.00
0.25	0.36	0.00	0.00	0.00	-2.20	4.82	0.00	-10.59	0.00
0.25	0.62	0.00	0.00	0.00	-1.94	3.78	0.00	-7.35	0.00
0.25	0.87	0.47	0.47	0.11	-1.69	2.86	1.34	-4.84	-2.27
0.25	1.12	0.85	1.32	0.35	-1.44	2.08	1.77	-3.00	-2.55
0.38	1.50	6.15	7.47	9.21	-1.06	1.13	6.94	-1.20	-7.37
0.38	1.88	8.13	15.60	15.29	-0.68	0.46	3.75	-0.31	-2.55
0.24	2.12	15.41	31.01	32.65	-0.44	0.19	3.00	-0.09	-1.32
0.25	2.37	21.89	52.90	51.84	-0.19	0.04	0.81	-0.01	-0.15
0.25	2.62	12.86	65.76	33.72	0.06	0.00	0.05	0.00	0.00
0.25	2.87	16.31	82.07	46.96	0.31	0.10	1.60	0.03	0.50
0.25	3.13	6.86	88.93	21.44	0.57	0.32	2.20	0.18	1.24
0.25	3.39	3.26	92.19	11.02	0.82	0.67	2.19	0.55	1.79
0.24	3.62	2.79	94.98	10.10	1.06	1.13	3.14	1.20	3.34
0.25	3.87	0.85	95.83	3.29	1.31	1.71	1.46	2.24	1.90
0.25	4.12	1.32	97.15	5.44	1.56	2.43	3.21	3.79	5.00
0.24	4.36	0.52	97.67	2.27	1.80	3.23	1.68	5.79	3.01
0.24	4.60	0.71	98.38	3.26	2.04	4.14	2.94	8.44	5.99
0.26	4.96	1.61	99.99	7.32	2.30	5.29	8.51	12.15	10.56
	sum	99.99		255.57			44.58		28.12
		2.50		2.56			0.67		0.88
		Mode		Mean			StandDev		Skewness



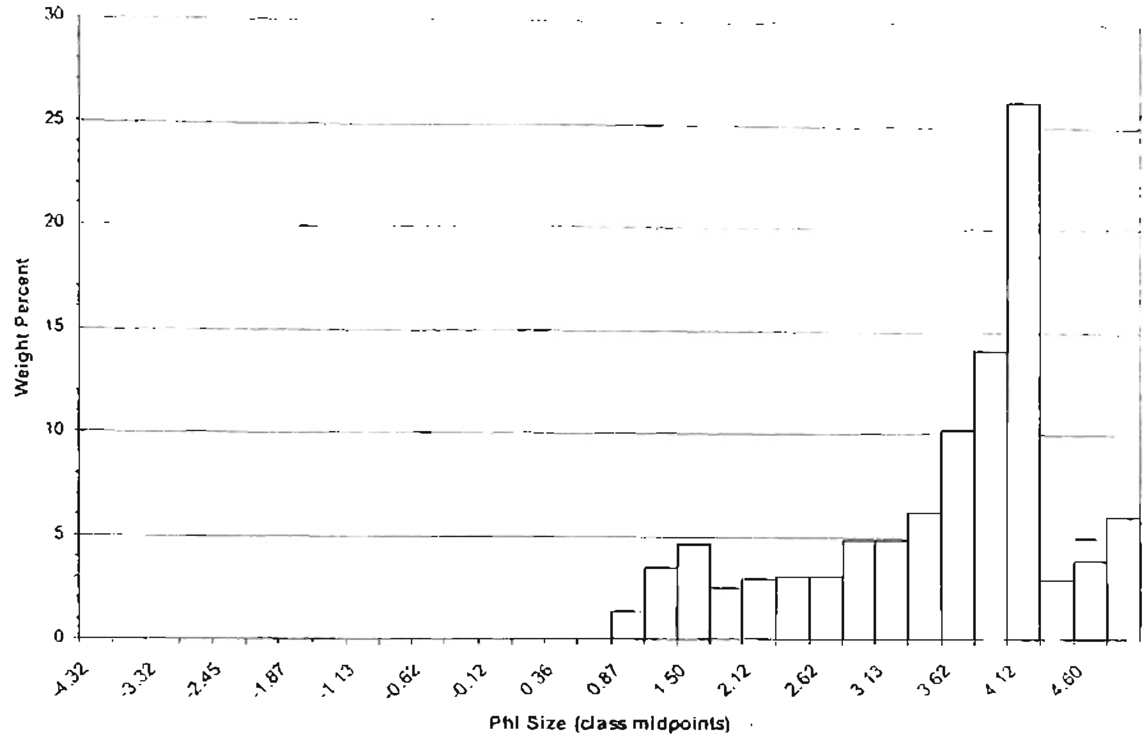
25
20
15
10
5
0
Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

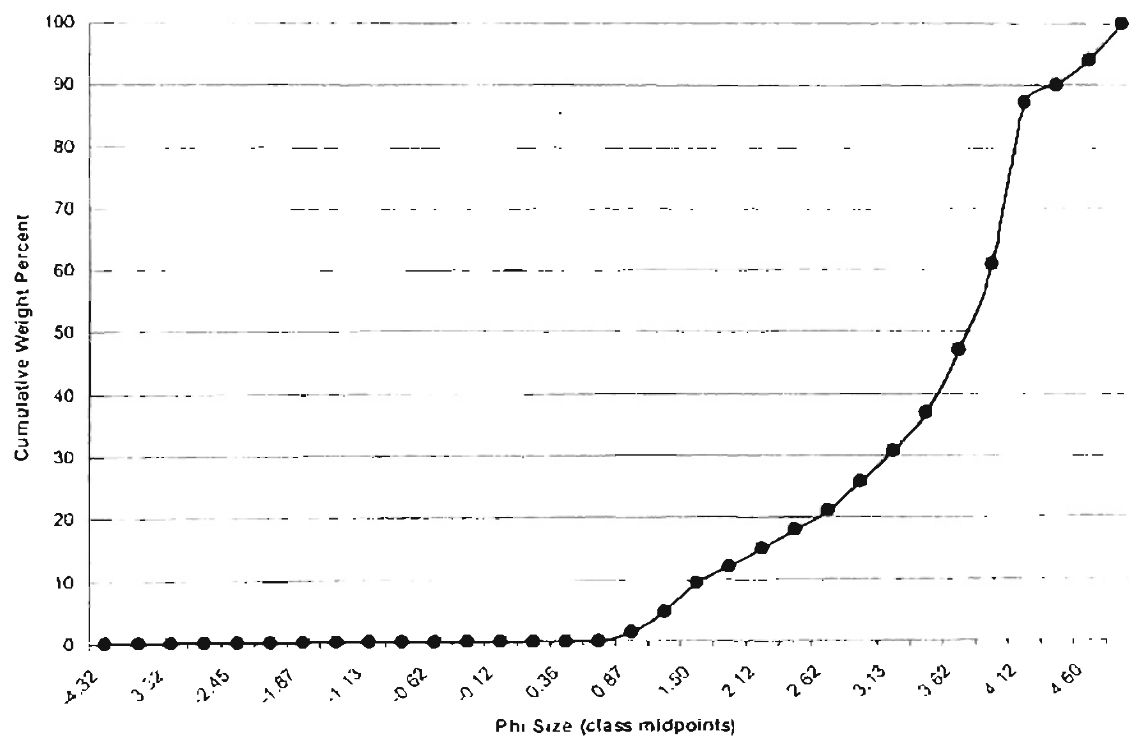


100
90
80
70
60
50
40
30
20
10
0
Cumulative Weight Percent
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60
Phi Size (class midpoints)

Harra-Newalla Road, 1.5 miles north of Hwy 9

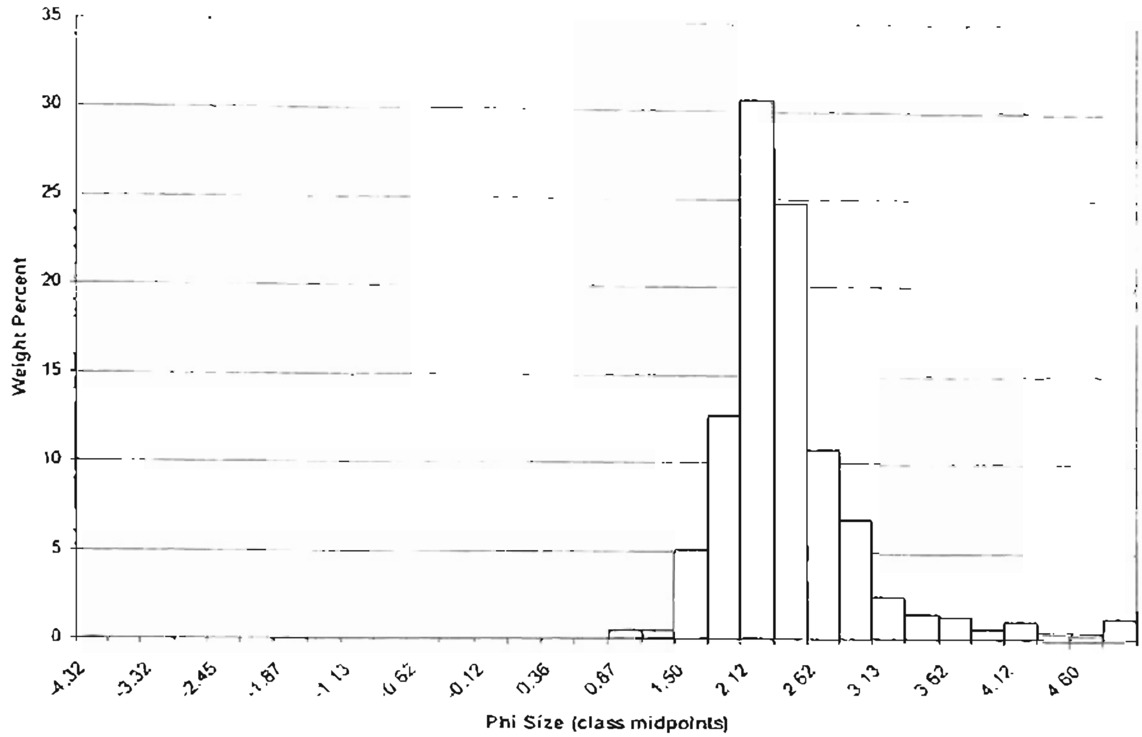
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	(m-x)^2	f(m-x)^2	(m-x)^3	f(m-x)^3
interval	-4.32	0.00	0.00	0.00	-7.79	60.71	0.00	-473.08	0.00
0.50	-3.82	0.00	0.00	0.00	-7.29	53.17	0.00	-387.73	0.00
0.50	-3.32	0.00	0.00	0.00	-6.79	46.13	0.00	-313.31	0.00
0.49	-2.83	0.00	0.00	0.00	-6.30	39.66	0.00	-249.77	0.00
0.38	-2.45	0.00	0.00	0.00	-5.92	35.07	0.00	-207.65	0.00
0.33	-2.12	0.00	0.00	0.00	-5.59	31.29	0.00	-175.05	0.00
0.25	-1.87	0.00	0.00	0.00	-5.34	28.56	0.00	-152.64	0.00
0.37	-1.50	0.00	0.00	0.00	-4.97	24.70	0.00	-122.74	0.00
0.37	-1.13	0.00	0.00	0.00	-4.60	21.12	0.00	-97.05	0.00
0.25	-0.87	0.00	0.00	0.00	-4.34	18.87	0.00	-81.99	0.00
0.25	-0.62	0.00	0.00	0.00	-4.09	16.75	0.00	-68.52	0.00
0.25	-0.37	0.00	0.00	0.00	-3.84	14.72	0.00	-56.50	0.00
0.25	-0.12	0.00	0.00	0.00	-3.59	12.88	0.00	-46.24	0.00
0.24	0.12	0.00	0.00	0.00	-3.35	11.24	0.00	-37.69	0.00
0.25	0.36	0.00	0.00	0.00	-3.11	9.65	0.00	-29.96	0.00
0.25	0.62	0.00	0.00	0.00	-2.85	8.15	0.00	-23.26	0.00
0.25	0.97	1.35	1.35	1.17	-2.60	6.77	9.14	-17.61	-23.77
0.25	1.12	3.47	4.82	3.38	-2.35	5.54	19.21	-13.02	-45.19
0.38	1.50	4.62	9.44	6.92	-1.97	3.89	17.97	-7.67	-35.44
0.38	1.88	2.50	11.94	4.70	-1.59	2.53	6.32	-4.02	-10.04
0.24	2.12	2.89	14.83	6.12	-1.35	1.83	5.28	-2.47	-7.13
0.25	2.37	3.08	17.91	7.29	-1.10	1.21	3.74	-1.34	-4.12
0.25	2.62	3.08	20.99	8.08	-0.85	0.72	2.21	-0.61	-1.88
0.25	2.87	4.82	25.81	13.85	-0.60	0.36	1.72	-0.21	-1.02
0.25	3.13	4.82	30.63	15.07	-0.34	0.12	0.57	-0.04	-0.20
0.25	3.38	6.17	36.80	20.85	-0.09	0.01	0.05	0.00	0.00
0.24	3.62	10.21	47.01	36.98	0.15	0.02	0.23	0.00	0.04
0.25	3.87	14.07	61.08	54.43	0.40	0.16	2.23	0.06	0.89
0.25	4.12	26.20	87.28	107.92	0.65	0.42	11.03	0.27	7.16
0.24	4.36	2.89	90.17	12.59	0.89	0.78	2.27	0.70	2.01
0.24	4.60	3.95	94.12	17.60	1.13	1.27	4.99	1.43	5.49
0.26	4.86	5.97	99.99	29.01	1.39	1.93	11.52	2.68	16.00
	sum	99.99		346.54			98.36		97.20
		4.24		3.47			0.99		-1.00
		Mode		Mean			StandDev		Skewness


Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

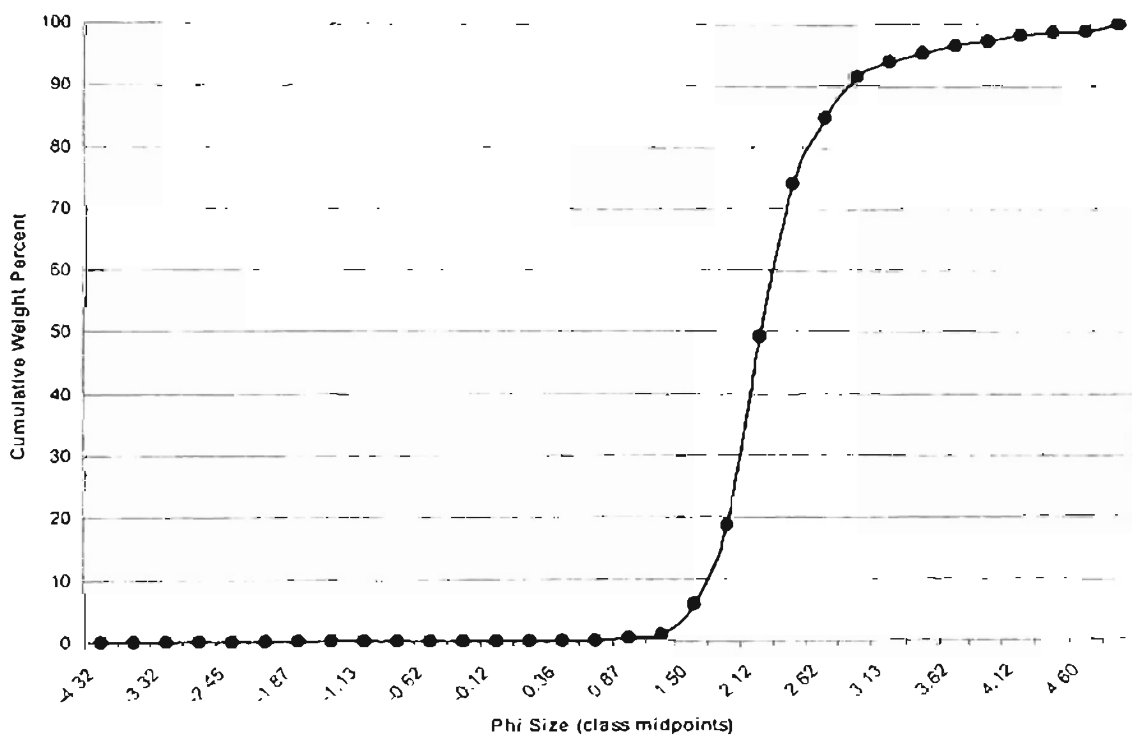

Cumulative Weight Percent
Phi Size (class midpoints)

Harra-Newalla Road, 1.6 miles north of Hwy 9

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interva	-4.32	0.00	0.00	0.00	-6.67	44.51	0.00	-237.00	0.00
0.50	-3.82	0.00	0.00	0.00	-6.17	38.09	0.00	-235.11	0.00
0.50	-3.32	0.00	0.00	0.00	-5.67	32.17	0.00	-132.47	0.00
0.49	-2.83	0.00	0.00	0.00	-5.18	26.81	0.00	-138.80	0.00
0.38	-2.45	0.00	0.00	0.00	-4.80	23.06	0.00	-110.71	0.00
0.33	-2.12	0.00	0.00	0.00	-4.47	20.02	0.00	-89.55	0.00
0.25	-1.87	0.00	0.00	0.00	-4.22	17.84	0.00	-75.38	0.00
0.37	-1.50	0.00	0.00	0.00	-3.85	14.82	0.00	-57.05	0.00
0.37	-1.13	0.00	0.00	0.00	-3.48	12.08	0.00	-41.08	0.00
0.25	-0.87	0.00	0.00	0.00	-3.22	10.40	0.00	-33.52	0.00
0.25	-0.62	0.00	0.00	0.00	-2.97	8.83	0.00	-26.25	0.00
0.25	-0.37	0.00	0.00	0.00	-2.72	7.38	0.00	-20.06	0.00
0.25	-0.12	0.00	0.00	0.00	-2.47	6.10	0.00	-15.06	0.00
0.24	0.12	0.00	0.00	0.00	-2.23	4.99	0.00	-11.13	0.00
0.25	0.38	0.00	0.00	0.00	-1.98	3.94	0.00	-7.83	0.00
0.25	0.62	0.00	0.00	0.00	-1.73	3.01	0.00	-5.22	0.00
0.25	0.87	0.47	0.47	0.41	-1.48	2.19	1.03	-3.25	-1.53
0.25	1.12	0.47	0.94	0.53	-1.23	1.52	0.71	-1.87	-0.88
0.38	1.50	5.02	5.96	7.52	-0.85	0.73	3.66	-0.62	-3.11
0.38	1.88	12.68	18.64	23.85	-0.47	0.22	2.79	-0.10	-1.31
0.24	2.12	30.58	49.22	64.80	-0.23	0.05	1.63	-0.01	-0.38
0.25	2.37	24.75	73.97	58.61	0.02	0.00	0.01	0.00	0.00
0.25	2.62	10.78	84.75	28.27	0.27	0.07	0.80	0.02	0.22
0.25	2.87	6.78	91.53	19.48	0.52	0.27	1.86	0.14	0.97
0.25	3.13	2.37	93.90	7.41	0.78	0.60	1.43	0.47	1.11
0.25	3.38	1.42	95.32	4.80	1.03	1.06	1.50	1.09	1.55
0.24	3.62	1.22	96.54	4.42	1.27	1.62	1.97	2.06	2.51
0.25	3.87	0.54	97.08	2.09	1.52	2.31	1.25	3.50	1.89
0.25	4.12	1.02	98.10	4.20	1.77	3.13	3.19	5.54	5.65
0.24	4.36	0.41	98.51	1.79	2.01	4.02	1.65	8.07	3.31
0.24	4.60	0.34	98.85	1.56	2.25	5.04	1.71	11.33	3.85
0.26	4.86	1.15	100.00	5.59	2.51	6.29	7.24	15.79	18.16
	sum	**100.00**		**235.31**			**32.43**		**32.01**
		2.24		**2.35**			**0.57**		**1.73**
		Mode		*Mean*			*StandDev*		*Skewness*



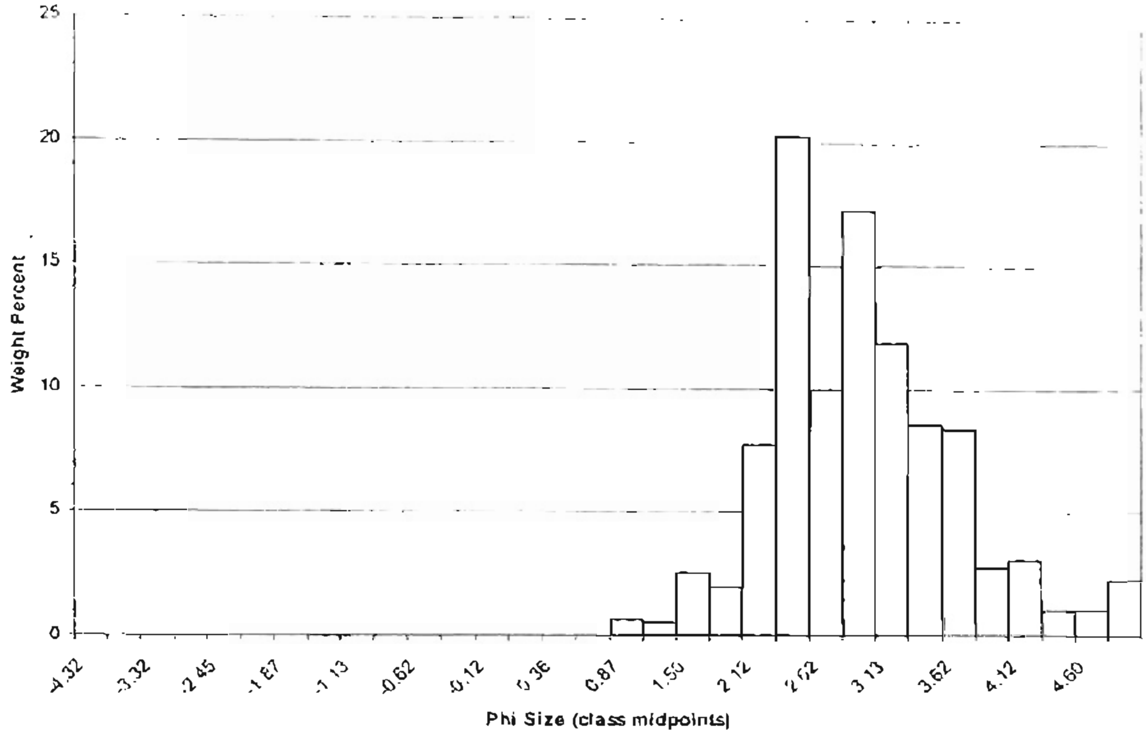
Weight Percent
Phi Size (class midpoints)

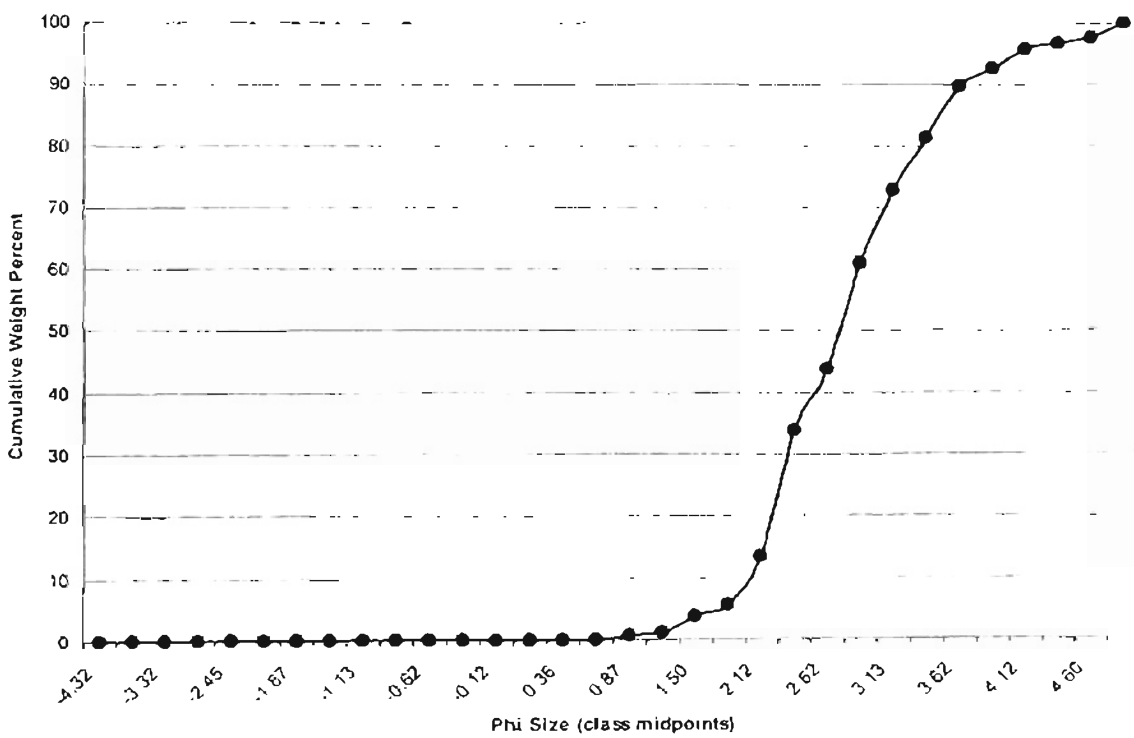


Cumulative Weight Percent
Phi Size (class midpoints)

Harra-Newalla Road, 2.1 miles north of Hwy 9

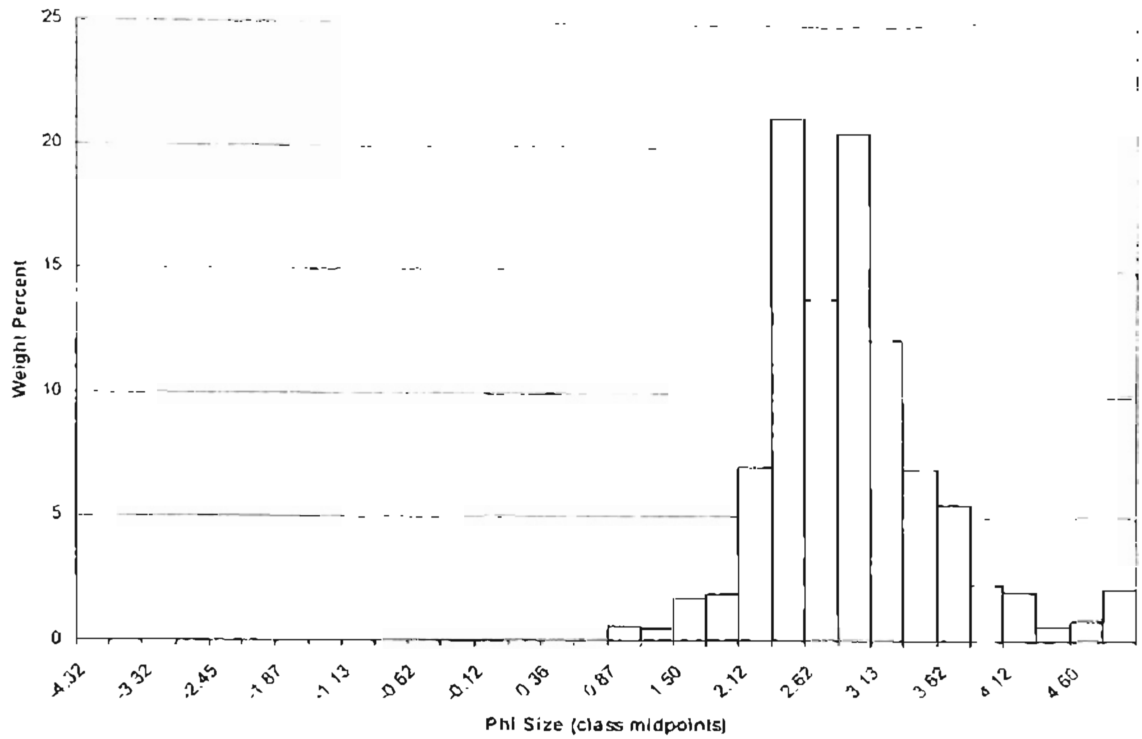
	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	$m-x$	$(m-x)^2$	$f(m-x)^2$	$(m-x)^3$	$f(m-x)^3$
interval	4.32	0.00	0.00	0.00	7.21	52.01	0.00	375.11	0.00
0.50	-3.82	0.00	0.00	0.00	-6.71	45.05	0.00	-302.37	0.00
0.50	-3.32	0.00	0.00	0.00	-6.21	38.59	0.00	-239.71	0.00
0.49	-2.83	0.00	0.00	0.00	-5.72	32.69	0.00	-186.92	0.00
0.38	-2.45	0.00	0.00	0.00	-5.34	28.53	0.00	-152.41	0.00
0.33	-2.12	0.00	0.00	0.00	-5.01	25.14	0.00	-126.05	0.00
0.25	-1.87	0.00	0.00	0.00	-4.76	22.70	0.00	-108.14	0.00
0.37	-1.50	0.00	0.00	0.00	-4.39	19.27	0.00	-84.59	0.00
0.37	-1.13	0.00	0.00	0.00	-4.02	16.12	0.00	-64.75	0.00
0.25	-0.87	0.00	0.00	0.00	-3.76	14.17	0.00	-53.34	0.00
0.25	-0.62	0.00	0.00	0.00	-3.51	12.33	0.00	-43.32	0.00
0.25	-0.37	0.00	0.00	0.00	-3.26	10.61	0.00	-34.56	0.00
0.25	-0.12	0.00	0.00	0.00	-3.01	9.06	0.00	-27.25	0.00
0.24	0.12	0.00	0.00	0.00	-2.77	7.69	0.00	-21.32	0.00
0.25	0.36	0.00	0.00	0.00	-2.53	6.38	0.00	-16.11	0.00
0.25	0.62	0.00	0.00	0.00	-2.27	5.17	0.00	-11.77	0.00
0.25	0.87	0.64	0.64	0.56	-2.02	4.09	2.62	-8.26	-5.29
0.25	1.12	0.54	1.18	0.30	-1.77	3.14	1.70	-5.57	-3.01
0.38	1.50	2.57	3.75	3.35	-1.39	1.94	4.98	-2.70	-6.93
0.38	1.88	1.93	5.69	3.33	-1.01	1.02	1.97	-1.03	-1.98
0.24	2.12	7.76	13.44	16.44	-0.77	0.59	4.61	-0.46	-3.56
0.25	2.37	20.29	33.73	40.05	-0.52	0.27	5.53	-0.14	-2.09
0.25	2.62	9.98	43.69	26.12	-0.27	0.07	0.71	-0.02	-0.19
0.25	2.87	17.24	60.93	49.54	-0.02	0.00	0.00	0.00	0.00
0.25	3.13	11.88	72.81	37.13	0.24	0.06	0.66	0.01	0.16
0.25	3.38	8.57	81.38	28.96	0.49	0.24	2.05	0.12	1.00
0.24	3.62	8.40	89.78	30.42	0.73	0.54	4.50	0.39	3.29
0.25	3.87	2.78	92.56	10.75	0.98	0.96	2.66	0.94	2.60
0.25	4.12	3.10	95.66	12.77	1.23	1.51	4.68	1.86	5.75
0.24	4.36	1.02	96.68	4.44	1.47	2.15	2.19	3.15	3.21
0.24	4.60	1.07	97.75	4.32	1.71	2.91	3.11	4.96	5.31
0.26	4.96	2.25	100.00	10.93	1.97	3.88	8.72	7.63	17.17
	sum	100.00		289.11			50.70		14.66
		2.50		2.89			0.71		0.41
		Mode		*Mean*			*StandDev*		*Skewness*

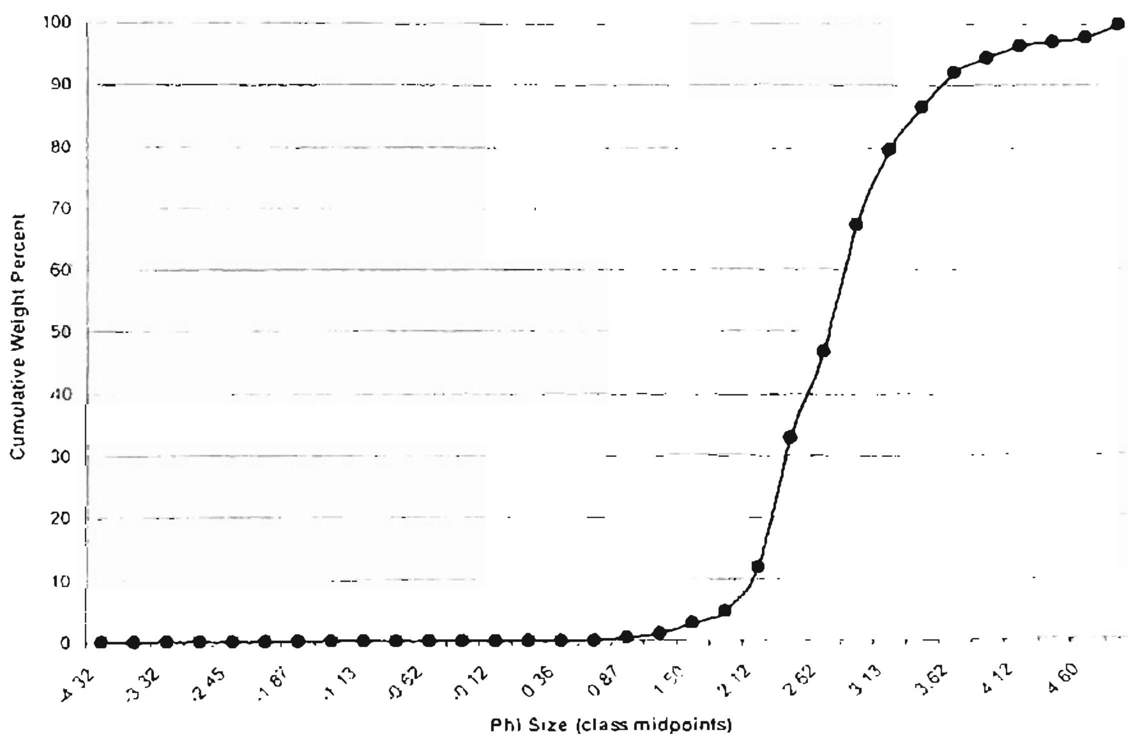

Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60


Cumulative Weight Percent
Phi Size (class midpoints)
-4.32
-3.32
-2.45
-1.87
-1.13
-0.62
-0.12
0.36
0.87
1.50
2.12
2.62
3.13
3.62
4.12
4.60

Harra-Newalla Road, 2.4 miles north of Hwy 9

	Phi Midpoint	Weight %	Cumulative Weight %	Product	Deviation	Deviation squared	Product	Deviation cubed	Product
	m	f		fm	m-x	(m-x)^2	f(m-x)^2	(m-x)^3	f(m-x)^3
interval	-4.32	0.00	0.00	0.00	-7.16	51.29	0.00	-367.36	0.00
0.50	-3.82	0.00	0.00	0.00	-6.66	44.38	0.00	-295.66	0.00
0.50	-3.32	0.00	0.00	0.00	-6.16	37.97	0.00	-233.96	0.00
0.49	-2.83	0.00	0.00	0.00	-5.67	32.12	0.00	-182.06	0.00
0.38	2.45	0.00	0.00	0.00	5.29	28.00	0.00	148.17	0.00
0.33	-2.12	0.00	0.00	0.00	-4.96	24.64	0.00	-122.32	0.00
0.25	-1.87	0.00	0.00	0.00	-4.71	22.22	0.00	-104.77	0.00
0.37	1.50	0.00	0.00	0.00	4.34	18.83	0.00	[illegible]	0.00
0.37	-1.13	0.00	0.00	0.00	-3.97	15.73	0.00	-62.36	0.00
0.25	-0.87	0.00	0.00	0.00	-3.71	13.80	0.00	-51.24	0.00
0.25	-0.62	0.00	0.00	0.00	-3.46	11.99	0.00	-41.50	0.00
0.25	-0.37	0.00	0.00	0.00	-3.21	10.29	0.00	-32.99	0.00
0.25	-0.12	0.00	0.00	0.00	-2.96	8.76	0.00	-25.92	0.00
0.24	0.12	0.00	0.00	0.00	-2.72	7.41	0.00	-20.19	0.00
0.25	0.38	0.00	0.00	0.00	-2.48	6.13	0.00	-15.17	0.00
0.25	0.62	0.00	0.00	0.00	-2.22	4.95	0.00	-11.01	0.00
0.25	0.87	0.59	0.59	0.51	-1.97	3.89	2.29	-7.66	-4.52
0.25	1.12	0.48	1.07	0.54	-1.72	2.97	1.42	-5.11	-2.45
0.38	1.50	1.70	2.77	2.55	-1.34	1.80	3.06	-2.42	-4.11
0.38	1.88	1.91	4.68	3.59	-0.96	0.92	1.76	-0.88	-1.69
0.24	2.12	7.03	11.71	14.90	-0.72	0.52	3.66	-0.37	-2.64
0.25	2.37	21.23	32.94	50.27	-0.47	0.22	4.73	-0.11	-2.23
0.25	2.62	13.89	46.83	36.43	-0.22	0.05	0.66	-0.01	-0.14
0.25	2.87	20.61	67.44	59.22	0.03	0.00	0.02	0.00	0.00
0.25	3.13	12.23	79.67	38.23	0.29	0.08	1.00	0.02	0.29
0.25	3.38	6.96	86.63	23.52	0.54	0.29	2.02	0.16	1.09
0.24	3.62	5.58	92.21	20.21	0.78	0.61	3.41	0.48	2.66
0.25	3.87	2.29	94.50	8.86	1.03	1.06	2.42	1.09	2.49
0.25	4.12	2.01	96.51	8.28	1.28	1.64	3.29	2.09	4.20
0.24	4.36	0.59	97.10	2.57	1.52	2.30	1.36	3.48	2.06
0.24	4.60	0.80	97.90	3.68	1.76	3.08	2.47	5.41	4.33
0.26	4.86	2.11	100.01	10.25	2.02	4.08	8.60	8.23	17.36
	sum	100.01		283.59			42.17		16.70
		2.50		2.04			0.65		0.61
		Mode		Mean			StandDev		Skewness


Weight Percent
Phi Size (class midpoints)


Cumulative Weight Percent
Phi Size (class midpoints)

VITA

Kathleen Kenney

Candidate for the Degree of

Master of Science

Thesis: OUTCROP-BASED LITHOFACIES AND DEPOSITIONAL SETTING OF ARSENIC-BEARING PERMIAN RED BEDS IN THE CENTRAL OKLAHOMA AQUIFER, CLEVELAND COUNTY, OKLAHOMA

Major Field: Geology

Biographical:

Education: Graduated from Turpin High School, Turpin, Oklahoma in May 1977; received an Associate Degree in Nursing from Seward County Community College in 1985; received a Bachelor of Science degree in Geology from Oklahoma State University, Stillwater, Oklahoma in May 2002. Completed the requirements for the Master of Science degree with a major in Geology at Oklahoma State University in July 2005.