Petrography of the Jackfork Sandstone at De Gray Dam, Clark County, Arkansas.

C. Edward Howard
Louisiana State University and Agricultural & Mechanical College

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_disstheses

Recommended Citation
https://digitalcommons.lsu.edu/gradschool_disstheses/845

This Dissertation is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Historical Dissertations and Theses by an authorized administrator of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.
This dissertation has been microfilmed exactly as received.

HOWARD, C. Edward, 1929-
PETROGRAPHY OF THE JACKFORK SANDSTONE AT DE GRAY DAM, CLARK COUNTY, ARKANSAS.

Louisiana State University, Ph.D., 1963
Geology

University Microfilms, Inc., Ann Arbor, Michigan
PETROGRAPHY OF THE JACKFORK SANDSTONE AT DE GRAY DAM, CLARK COUNTY, ARKANSAS

A Dissertation
Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy
in
The Department of Geology

by
C. Edward Howard
B.S., Duke University, 1953
M.S., North Carolina State College, 1955
June, 1963
ACKNOWLEDGMENT

The writer is indebted to Dr. John C. Ferm, Associate Professor of Geology at Louisiana State University, for his guidance and advice throughout the study, and to Dr. A. E. Sandberg, Professor and Chairman of the Department of Geology, who critically read the manuscript and made many useful suggestions.

Dr. B. H. Farthing, Chief Statistician, Louisiana State University Agricultural Experiment Station, helped the author through much of the statistical study. Mr. John E. Rovik, Instructor of Geology at Louisiana State University, helped with the clay X-rays. Dr. Ulrich Jux, of the University of Cologne, Germany, instructed the author in the spore study. Comments on the spore identifications were made by Dr. Gerhard O. W. Kremp, of the University of Arizona, based on photomicrographs of the spores.

The author also wishes to thank the Geology Branch of the Waterways Experiment Station in Vicksburg, Mississippi, for making the cores available for study, and Dr. Charles R. Kolb and Mr. W. B. Steinriede, Jr., both of the Waterways Experiment Station, for their help in the field and in the selection of the cores.

Finally, more than thanks is due the author's wife, who typed the manuscript, and who was a source of help and inspiration during the entire project.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENT</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Location and purpose of study</td>
<td>1</td>
</tr>
<tr>
<td>The Jackfork sandstone</td>
<td>3</td>
</tr>
<tr>
<td>II GEOLOGY OF THE JACKFORK SANDSTONE</td>
<td>6</td>
</tr>
<tr>
<td>Regional geology</td>
<td>6</td>
</tr>
<tr>
<td>Geology of the De Gray dam area</td>
<td>11</td>
</tr>
<tr>
<td>III TECHNIQUES AND RESULTS</td>
<td>13</td>
</tr>
<tr>
<td>Methodology</td>
<td>13</td>
</tr>
<tr>
<td>Mineral composition</td>
<td>21</td>
</tr>
<tr>
<td>Grain size and sorting</td>
<td>26</td>
</tr>
<tr>
<td>IV ANALYSIS OF THE DATA</td>
<td>30</td>
</tr>
<tr>
<td>Mineral composition</td>
<td>30</td>
</tr>
<tr>
<td>Grain size, sorting and structure</td>
<td>48</td>
</tr>
<tr>
<td>Differences between rock types</td>
<td>52</td>
</tr>
<tr>
<td>Differences within rock types</td>
<td>59</td>
</tr>
<tr>
<td>V SUMMARY</td>
<td>67</td>
</tr>
<tr>
<td>Source area</td>
<td>67</td>
</tr>
<tr>
<td>Environment of deposition</td>
<td>67</td>
</tr>
<tr>
<td>SELECTED REFERENCES</td>
<td>70</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>76</td>
</tr>
<tr>
<td>Appendix A - Mineral composition and grain size data of the thin sections</td>
<td>76</td>
</tr>
<tr>
<td>Appendix B - Mineral composition and grain size data of the total cored section and of each rock type</td>
<td>182</td>
</tr>
<tr>
<td>Appendix C - Stratigraphic distribution of the rock types</td>
<td>195</td>
</tr>
<tr>
<td>Appendix D - Recovery, concentration, and identification of spores</td>
<td>201</td>
</tr>
<tr>
<td>VITA</td>
<td>204</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>DESCRIPTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>R x C Contingency Table of All 11 Rock Types Based on Four Compositional Classes</td>
<td>32</td>
</tr>
<tr>
<td>II</td>
<td>Chi-Square Values and F Test of All 11 Rock Types Based on Four Compositional Classes</td>
<td>36</td>
</tr>
<tr>
<td>III</td>
<td>Chi-Square Values and F Test of Sandstones vs. Shales Based on Four Compositional Classes</td>
<td>37</td>
</tr>
<tr>
<td>IV</td>
<td>R x C Contingency Table of the Sandstones Based on Siderite vs. All Others</td>
<td>39</td>
</tr>
<tr>
<td>V</td>
<td>Chi-Square Values and F Test of the Sandstones Based on Siderite vs. All Others</td>
<td>41</td>
</tr>
<tr>
<td>VI</td>
<td>R x C Contingency Table of the Sandstones Based on Illite vs. All Others</td>
<td>43</td>
</tr>
<tr>
<td>VII</td>
<td>Chi-Square Values and F Test of the Sandstones Based on Illite vs. All Others</td>
<td>45</td>
</tr>
<tr>
<td>VIII</td>
<td>2 x 2 Chi-Square and Q Test of Association of Quartz Grain Size and Illite Content</td>
<td>47</td>
</tr>
<tr>
<td>IX</td>
<td>Bartlett's Test of Thin Sections Within the Entire Core</td>
<td>49</td>
</tr>
<tr>
<td>X</td>
<td>Results of Bartlett's Tests on Thin Sections Within Each Rock Type</td>
<td>53</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1  Geologic maps of the Ouachita Mountains and the De Gray Dam area ............................................................................. 2
Figure 2  Mississippian-Pennsylvanian stratigraphic section, central Ouachita Mountains, Oklahoma ................................... 8
Figure 3  Division of cores into rock types ................................................. 15
Figure 4A Graphic log of Core G-9 ......................................................... 16
Figure 4B Graphic log of Core G-8 and G-9 continued ......................... 17
Figure 5  Example of graphs used to determine the number of grains which should be measured in each thin section ....................................................................................................... 29
Figure 6  Comparison of the average grain size and variance of the 11 rock types and the entire cored section used in the study ........................................................................................................ 54
Figure 7  Relationship of depositional environment to rock types ........................................................................................................... 57
Figure 8  A comparison of sandstone rock type variables ..................... 60
Figure 9  A comparison of shale rock type variables ............................... 63
Figure 10  Stratigraphic variations in energy efficiency or duration and energy intensity as interpreted from sorting and average grain size of the rock types ............................................................................. 66
ABSTRACT

The Jackfork sandstone of the Ouachita Mountains of Arkansas and Oklahoma represents part of a series of thick geosynclinal sediments. In typical development it consists of 5,600 to 5,800 feet of alternating sandstone and dark gray shale, sandstone being the most abundant rock type. The total thickness, average grain size, and percentage of sandstones increase in an easterly direction, toward the inferred source area.

In 1960 the U. S. Army Corps of Engineers began investigation of the De Gray Dam site ten miles northwest of Arkadelphia, Arkansas, on the Caddo River. In this area the Jackfork is about 6,000 feet thick and comprises about 70% sandstone and 30% shale. During the course of exploratory drilling in the dam site area a number of cores of fresh rock from the Jackfork were recovered and these cores were made available for study. Two cores considered to be representative of the sedimentary rock types observed in the area were selected for a macroscopic and microscopic study of structures, grain size, sorting, and mineral composition in order to determine something of the nature of the source area and the environment of deposition of the Jackfork sediments. Organic evidence was sparse and limited to a few spores and broken plant fragments.

The cores used in this study consist of 2.1% conglomerate, 56.4% sandstone and 41.5% shale and silty shale. The conglomerates are composed of small orthoquartzite pebbles and scattered angular shale
fragments and occur in beds up to 5.5 feet thick. The sandstones are composed of a framework of almost pure quartz grains with varying amounts of illite, siderite, and silica matrix and cement. The sandstones occur in both structureless massive beds over 50 feet thick and in units up to 5.6 feet thick showing parallel bedding planes and occasional small scale cross-bedding. Individual beds within these units range from 1/8 inch to two inches thick. The thinner sandstone beds are commonly interbedded with the shales and silty shales. These shales are composed primarily of illite with varying amounts of siderite and silt sized quartz grains. The more silty layers, like many thin sandstones, occasionally show small scale cross-bedding and penecontemporaneous deformation. The silty laminae vary from approximately 1/16 inch to 1/2 inch in thickness. Graded bedding shales grade from larger (or more numerous) silt sized grains at the bottom to smaller (or less numerous) silt sized grains at the top. These layers vary from approximately 1/4 to two inches in thickness.

A relatively simple mineral suite throughout the thick sedimentary body and the presence of orthoquartzite rock fragments suggest a sedimentary source for the Jackfork rocks. Distinctive differences in grain size and sorting show that the energy systems at the site of deposition were very effective in reworking and sorting the sediments into different rock types. The massive sandstones are not as well sorted as the bedded sandstones, but the very high quartz content of these massive rocks indicates that even though deposition was rapid most of the fine material initially present was eliminated by winnowing. Bedded sandstones with small scale cross-bedding, and a wide range of average grain sizes with excellent sorting are probably the
product of normal aqueous currents of varying velocities rather than
turbidity currents. The intimate association of these bedded sand-
stones with the shales and silty shales implies that deposition of all
these sediments probably took place in essentially the same general
environment which was probably relatively shallow water.
CHAPTER I

INTRODUCTION

LOCATION AND PURPOSE OF STUDY

In 1960 the U. S. Army Corps of Engineers began the De Gray Dam project ten miles northwest of Arkadelphia, Arkansas, on the Caddo River. The dam site is in a gorge through a ridge of the Jackfork sandstone which is a prominent ridge builder all along its outcrops in the Ouachita Mountains (fig. 1).

During the course of exploratory drilling in the dam site area a number of cores of fresh rock from the Jackfork were recovered and these cores were made available to the writer for study. After the writer examined the cores available two were selected, with the help of Dr. Charles R. Kolb, of the Waterways Experiment Station in Vicksburg, Mississippi. These cores were representative of all the rock types observed and were sufficiently overlapping and close together to be correlated, giving the thickest continuous stratigraphic sequence possible. The weathered tops of the cores and the overlapping section of one of the cores were not used in the study. The selected borings came from a zone slightly above the stratigraphic center of the Jackfork in the study area.

The purpose of this study is to contribute information relevant to an understanding of the environment of deposition and the nature of the source area of a section of the Jackfork sandstone at the De Gray
Figure 1 Geologic maps of the Ouachita Mountains and the De Gray Dam area
dam in Arkansas, based on the representative rock types contained in these cores. To this end the investigation was concerned primarily with sedimentary structures and thin section studies of mineral composition, grain size, and sorting of the sediments contained in the cores.

THE JACKFORK SANDSTONE

The Jackfork sandstone was named by Taff (1902) for Jackfork Mountain, Oklahoma. It is exposed in the Ouachita Mountains of Arkansas and Oklahoma and represents a part of a thick series of geosynclinal sediments. In typical development the Jackfork consists of 5,600 to 5,800 feet of alternating sandstone and dark gray shale, sandstone being the prevailing rock type. The total thickness, average grain size, and percentage of sandstones increase in an easterly direction, toward the inferred source area.

The most intensive study of the Jackfork has been in the west and central areas of the Ouachita Mountains, where it has been divided into a group of five formations. The division of the Jackfork into formations has not yet been extended through Arkansas. The age of the Jackfork has been a subject of controversy for many years; however, the Oklahoma Geological Society has now accepted Cline's evidence as proof of a Mississippian age (Branson, 1957), and it is this age classification that is used in this manuscript.

In eastern Oklahoma the Jackfork is described as a series of dark gray shales intricately interbedded with thin, even beds of sandstone in a manner suggesting a rhythmic or cyclic deposition characteristic of flysch facies (Cline, 1960). Abundant sole markings, sporadic worm
trails, and convolute bedding are also present. Directional paleo-current features of the sandstones such as flute casts, groove casts, and bounce casts indicate that the currents transporting the Jackfork sediments flowed from the east to slightly south of due west (Cline, 1960). Cross-bedding is uncommon except in the Game Refuge formation at the top of the Jackfork sandstone where small scale cross-bedding with ripple marks, including some interference ripple marks, are common. Sole markings are rare. With the possible exception of this upper part of the Jackfork the sediments are believed to have been deposited below wave base in relatively deep water, the normal deep water shale deposition being interrupted by turbidity currents bringing in sands foreign to the environment (Shelburne, 1960).

In western Arkansas, but east of the general area discussed above, the Jackfork is described as consisting of largely non-rhythmic, shallow water sediments, with some rhythmically interbedded thin sandstones, shales, and siltstones (Bokman, 1953). Here ripple markings, laminations parallel to the bedding, and small scale cross-laminations are fairly common. Large scale cross-bedding is unknown. Bedding plane structures found in the Jackfork by Bokman (1953) are considered to be of mixed origin. He believes that some of the structures originated as rill or drag markings in the littoral zone and that local and ephemeral scouring action by turbidity flows might have been partly responsible for others. Bokman believes that the source rocks were probably metasediments which were made available by the folding and uplifting of a portion of the earlier filled geosyncline.

The different interpretations of environmental conditions seem to
be based largely on different features observed in different locali-
ties of the Jackfork rather than on differing opinions concerning
similar features. If this is true then the environment of deposition
of the Jackfork sandstone may be assumed to have been one of relatively
deep water in the west while a more shallow water environment obtained
in the east, a thesis which is consistent with the conclusion that the
source area was to the east or southeast.
The Ouachita Mountains represent the most northern exposure of the Ouachita folded geosyncline which disappears beneath the coastal plain sediments to the west, south, and east. The geosyncline has been traced in the subsurface southeastward into southern Alabama. From the western Ouachita Mountains the geosyncline has been traced in the subsurface south-southwest into central Texas. From here it curves west and northwest into west Texas and then turns south, apparently passing into Mexico.

The Ouachita Mountains form a lens-shaped area 50 to 60 miles wide and 220 miles long, extending from Little Rock, Arkansas, in the east, to Atoka, Oklahoma, in the west. The northern boundary of this physiographic and structural province is the Arkansas Valley and the southern boundary is the Gulf Coastal Plain. The area consists of ridge-like mountains and intermontane valleys which parallel the regional strike of the fold axes, several intermontane basins, and, on the south, a piedmont plateau. Relief increases from about 250 feet near Little Rock to nearly 2,000 feet near the Arkansas-Oklahoma border, where the elevation reaches 2,900 feet.

The structure of the Ouachitas is essentially that of an anticlinorium. The individual folds range from open to closely compressed
anticlines and synclines. Fan folds are also present, some of which are normal and some inverted. The faults are chiefly reverse and thrust faults.

Rocks of the Ouachita Mountains include a series of relatively thin Early Paleozoic or pre-Stanley deposits of black graptolitic shales, bedded cherts, novaculites, and fine sandstones of Ordovician, Silurian, and Devonian age which reach a total thickness of 3,000-6,000 feet (King, 1951). These rocks are overlain by a thick section of Late Paleozoic shales and sandstones.

The Late Mississippian and Early Pennsylvanian strata of the Stanley-Jackfork-Johns Valley-Atoka sequence have an aggregate thickness of approximately 22,000 feet in the heart of the Ouachitas. These rocks are believed to represent the orogenic phase sediments of the Ouachita geosyncline. A stratigraphic section is shown in figure 2. Excellent summaries of the present knowledge of these sediments are given by Bokman (1953), Cline (1960), and Shelburne (1960).

The Stanley shale reaches a thickness of approximately 11,000 feet in the Central Ouachitas where it has been divided into three formations. The strata consist of shale, graywacke, siltstone, siliceous shale, and tuff, in decreasing order of abundance, the sandstones becoming prominent in the upper 1,500 feet. Typically, beds are arranged in a rhythmic fashion of alternating shale and graywacke with a few abnormally thick shale and graywacke units. Cross-bedding, although not common, has been noted. The sediments are believed to be mainly deep or moderately deep water deposits. The source rocks are believed by Bokman (1953) to be primarily crystalline, not sedimentary, a conclusion reached on the basis
<table>
<thead>
<tr>
<th>System</th>
<th>Series</th>
<th>Group or Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvanian</td>
<td>Atokan</td>
<td>Rocks of Atoka lithology</td>
</tr>
<tr>
<td></td>
<td>Morrowan</td>
<td>Johns Valley shale</td>
</tr>
<tr>
<td>Mississippian</td>
<td>Chesterian</td>
<td>Game Refuge sandstone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wesley siliceous sh.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Markham Mill fm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prairie Mountain fm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wildhorse Mountain fm.</td>
</tr>
<tr>
<td></td>
<td>Meramecian</td>
<td>Chickasaw Creek siliceous sh.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moyers fm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ten Mile Creek sh.</td>
</tr>
</tbody>
</table>

From Cline and Shelburne, 1959

Figure 2. Mississippian-Pennsylvanian stratigraphic section, central Ouachita Mountains, Oklahoma
of a thin section study of the elongation of quartz grains. In the western and northwestern portions of the frontal Ouachitas the Stanley thins rapidly. The Jackfork sandstone lies conformably on the Stanley shale with a gradational contact.

The Jackfork sandstone crops out around the core of the Ouachita Mountains throughout the province and increases in thickness from approximately 1,700 feet northeast of Atoka, Oklahoma, to approximately 6,500 feet in eastern Oklahoma. The average sandstone-shale ratio is on the order of three to two, but this will vary regionally and with stratigraphic position (Cline, 1960). The average ratio of sandstone to shale seems to be somewhat less in the upper part of the Jackfork than in the lower. Bokman (1953) reports an average ratio of 70% sandstone, 27% shale, and 3% siltstone in measured sections totaling 1,038 feet. Siltstone is generally interbedded with shale. Individual massive sandstones have a maximum observed thickness of 43 feet unbroken by thinner zones of shale. Shale beds, unbroken by thinner beds of sandstone, have a maximum observed thickness of 57 feet. West of this area Cline (1960) reports a maximum observed thickness of only eight feet of sandstone, unbroken by shale. The sandstones of the Jackfork seem to be somewhat cleaner than those of the Stanley, having the appearance of quartzites, and although relatively fine grained, are coarser than the Stanley sandstones. An average Jackfork sandstone described by Bokman (1953) has a mean grain size of 2.80 µ and is called a sub-graywacke with 0-2% feldspar.

The Johns Valley shale overlies the Jackfork sandstone in the northwestern and central Ouachitas. In characteristic development it
includes 425 to 900 feet of prevailing shaly strata with some thin interbedded sandstones in the upper portion. In a belt 25-30 miles wide and extending from near Atoka, Oklahoma, in the western part of the frontal Ouachitas, eastward for about 125 miles into Arkansas, the shale contains limestone erratics ranging in size from pebbles to boulders 40 feet or more in diameter. Of the various theories advanced to explain the transportation of the smaller erratics to the site of deposition Cline (1960) considers ice rafting to be the most logical. He believes the larger blocks may have slid down the steep western and northern slopes of the Ouachita trough on a bottom lubricated by accumulating black muds.

The Atoka formation overlies the Jackfork sandstone in the southeast and the Johns Valley shale in the central and northwestern Ouachitas. The Atoka is extremely variable in both thickness and lithology. It reaches a thickness of 6,300 feet (Shelburne, 1960), but the complete thickness is not present in the Ouachita Mountains, the upper portion having been removed by erosion (Cline, 1960). The rocks are mainly light gray, silty, micaceous, and flaky shale with lenses and beds of sandstone. The sandstones are generally poorly sorted, micaceous, and moderately argillaceous (Goldstein, 1959).

In summary, the relatively thin pre-Stanley rocks seem to represent a period of very slow sedimentation in an essentially starved trough while the very thick Stanley-Jackfork-Johns Valley-Atoka sequence was deposited during a period of very active tectonism. In the western Ouachitas the repeated alternations of dark shales and gray sandstones, lack of cross-bedding, and the presence of flute casts, groove casts,
and bounce casts are interpreted as features of turbidites and the sediments are believed to have been laid down in relatively deep water. The orientation of the bedding structures and the eastward thickening of the sediments seems to indicate that the source area was to the east or southeast. In the eastern Ouachitas the character of the Jackfork sandstone has changed somewhat. The sands are cleaner, cross-bedding and ripple markings are fairly common, and massive sandstones reach a thickness of 43 feet in one observed section. These features have led Bokan (1953) to the conclusion that, in this area at least, the Stanley-Jackfork sequence represents an over-all trend from deep to shallow water deposition.

**GEOLOGY OF THE DE GRAY DAM AREA**

The De Gray Dam is in the south flank of the Ouachita Mountains in the extreme eastern outcrop of the Jackfork sandstone close to where it plunges beneath the coastal plain sediments. A discussion of the geology of this area is contained in the U. S. Army Waterways Experiment Station Design Memorandum No. 5-1 (1961).

The Stanley shale crops out in the northern part of the area (fig. 1) and is composed of alternating layers of sandstones and shale in a ratio of about 60% shale to 40% sandstone.

The Jackfork sandstone conformably overlies the Stanley shale with a contact which is gradational over several tens of feet. The Jackfork is about 70% sandstone and approximately 6,000 feet thick in the area of the dam site. The sandstones are light to dark gray or brown and medium to fine grained with sporadic lenses of coarse quartz grains. The
shales are dark gray to black, thinly bedded, hard, and fissile. The shales occur as thick beds but more commonly as thin layers between the more massive beds of sandstones.

Correlation of individual beds over long distances is impossible and often difficult over distances of even a few hundred feet, as the sandstones and shales grade rapidly from one to another. The beds at the dam site dip south at an average of 45° and strike N 88° W. Two miles south of the dam site the dip of the beds flattens to 14°-18° and the strike varies from N 80° E to N 90° E.

Joints in the sandstones are up to 1/4" wide, some being partially filled with silica. Joints in the shales are less pronounced and many are tightly sealed. Transverse faults are numerous. The Caddo River gorge through the Jackfork sandstone follows a large transverse fault. Bedding plane faults, evidenced by slickensides and clay seams, probably occurred during tilting of the beds.

The Jackfork is conformably overlain by the Atoka formation in the area of the dam site. It crops out to the south of the Jackfork and dips beneath the Cretaceous sediments of the coastal plain. The Atoka is composed of approximately 80% shale with fine grained sandstones occurring mainly as thin beds a few inches to a foot thick.
CHAPTER III

TECHNIQUES AND RESULTS

METHODOLOGY

The two cores selected for study are approximately 2.15 inches in diameter and were drilled vertically. The total length of core studied was 297 feet. At the De Gray dam the Jackfork has a dip of 45°, therefore the 297 feet of vertical core represents a total section of 210 feet.

The cores contain a series of repeated sandstones, shales and silty shales. Features in a core which would reflect the influence of the environment of deposition, and in part, the nature of the source area, include the evidence of fossils, and the rock properties of grain size, sorting, structure, and composition.

Fossils are sparse in the Jackfork. Although the shales contain black carbonaceous material, only a few megascopic but small plant fragments were found in the cores. Fifty-five samples were treated for the removal and concentration of spores. The recovery was small, both in number and genera. The techniques and results of this analysis are contained in the appendix. No shells or shell fragments were identified in the cores.

The investigation was consequently concerned primarily with the rock properties of grain size, sorting, structure, and color. The cores
were divided into 11 rock types based on these variables as they were observed by megascopic examination (fig. 3).

A description of the rock types based on these variables follows.

The conglomerate is poorly sorted and massive in structure. Grains with apparent long axes up to -2.66 $\phi$ were measured in thin section and still larger grains were observed in hand specimens, but none exceeding -4 $\phi$. The vast majority of grains are rounded quartz or quartzite. A few angular shale fragments were seen. In general the lower contacts of the conglomerates are quite sharp and the upper contacts are gradational over a few inches to a foot or more.

The massive sandstones were divided on the basis of color into two groups, brown and gray. Except for this difference in color there is no obvious megascopic difference between the two groups. Neither shows visible structure or variations in texture. Radiographs were made of four slices of the massive sandstones in the manner described by Hamblin (1962) on the strength of the possibility that they might show some otherwise invisible structure, but they revealed no structure or variations in texture. The thickest unbroken sequence of massive sandstone in the cores is approximately 50 feet, but because this unit occurs at the top of the core, its total thickness is unknown. Of the 50 feet contained in the core the upper 14.4 feet was weathered and therefore it was not included in the study. It should be noted that the section referred to above is composed of massive brown sandstone only. The total cored thickness of massive sands, pebbly sands, bedded sands, and conglomerates, down to the first appearance of shale, is approximately 115 feet (fig. 4). These measurements are vertical and represent
<table>
<thead>
<tr>
<th></th>
<th>Coarse Grained Rocks</th>
<th>Medium Grained Rocks</th>
<th>Fine Grained Rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.1 feet</strong></td>
<td>6.1 feet (2.1% of total core)</td>
<td>167.8 feet (56.4% of total core)</td>
<td>123.1 feet (41.5% of total core)</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>Brown 86.3 feet (29.0% of total core)</td>
<td>Gray 81.5 feet (27.4% of total core)</td>
<td></td>
</tr>
<tr>
<td><strong>Structure or Sorting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conglomerate</strong></td>
<td>Massive Brown Sandstone 72.2 feet (24.3% of total core)</td>
<td>Massive Gray Sandstone 51.4 feet (17.3% of total core)</td>
<td>Massive Shale Rock Type 08 2.6 feet (0.9% of total core)</td>
</tr>
<tr>
<td><strong>Rock Type 07 6.1 feet</strong></td>
<td>Bedded Brown Sandstone 2.1 feet (0.7% of total core)</td>
<td>Bedded Gray Sandstone 23.5 feet (9.6% of total core)</td>
<td>Disturbed Structure Shale Rock Type 09 32.6 feet (11.0% of total core)</td>
</tr>
<tr>
<td></td>
<td>Pebbly Brown Sandstone 12.0 feet (4.0% of total core)</td>
<td>Pebbly Gray Sandstone 1.6 feet (0.5% of total core)</td>
<td>Graded Bedding Shale Rock Type 10 33.8 feet (11.4% of total core)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mixed Disturbed Structure and Graded Bedding Shale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rock Type 11 54.1 feet (18.2% of total core)</td>
</tr>
</tbody>
</table>

*All measurements refer to core length, not stratigraphic thickness.

Figure 3. Division of cores into rock types.
Core G-9
Elevation at 20' Depth = 311.1'

1

01 Massive Brown Sandstone

02 Bedded Brown Sandstone

03 Pebby Brown Sandstone

04 Massive Gray Sandstone

05 Bedded Gray Sandstone

06 Pebby Gray Sandstone

07 Conglomerate

08 Massive Shale

09 Disturbed Structure Shale

10 Graded Bedding Shale

11 Mixed Disturbed Structure and Graded Bedding Shale

Figure 4A. Graphic log of Core G-9.
NOTE: The correlated section of Core G-8 which is stratigraphically below Core G-9 is slightly updip and was taken topographically downhill from G-9, therefore the core depth is not in sequence.

Figure 4B. Graphic log of Core G-8 and G-9 continued.
apparent thickness. The beds dip at an angle of approximately 45°; therefore true thickness can be determined by multiplying the values by 0.707.

The pebbly sandstones were also divided into brown and gray groups. The color and grain size distinction of the pebbly gray group was difficult, and later petrographic analyses indicated no significant difference between the pebbly gray and the massive brown sandstones. The pebbly sandstones are much like the massive sandstones (in which they are generally contained) except for the presence of pebbles and sporadic shale fragments in the former. Both upper and lower contacts with the massive sandstones are typically gradational.

The bedded sandstones were also divided into gray and brown groups. Bedded sandstones are much more abundant in the gray than in the brown group. Individual beds range from approximately 1/8 to two inches thick. The bedding plane is usually marked by a high percentage of clay. Some small scale cross-bedding is visible, and some of the more extensive laminae may actually represent cross-bedding which is too large to be apparent in the cores. Penecontemporaneous slump or flow structures are present but not common. The bedded sandstones grade into the disturbed structure shales as determined by the megascopic criteria of grain size and thickness of sets of beds. Consequently it was necessary to establish operational divisions of the two types. These divisions were based on bedding, which was a much more reliable method than a megascopic division based on grain size; however, decreasing grain size seemed to be definitely associated with decreasing bed thickness. If the total set of laminated beds was more than 0.2 feet thick it was called bedded sandstone; if less it was called disturbed structure shale.
Disturbed structure shale is a term used in this paper to include all shales or silty shales which do not show simple vertically graded bedding with no slump or flow structures or silt layers. The structures are accentuated by silty beds, some showing small scale cross-bedding. Internal slumping and loading structures are present. Flowage folds or rolls are also present but rare. The silty laminae vary from approximately 1/16 inch to 1/2 inch thick. Several of these laminae may occur together between silt-poor shale layers. The silty layers are interbedded with silt-poor shales generally in an alternating manner, but usually with one type or the other dominating in thickness by a variable amount. The silt-poor laminae vary in thickness from approximately 1/4 inch to one inch. Several of these laminae may occur together without intervening silty layers. The silt-poor laminae usually show some indication of grading from coarser grained (or more numerous grains) at the bottom to finer grained (or less numerous grains) at the top. Any structures present in these silt-poor laminae seem to be the result of slumping or loading. Generally upper and lower contacts between the silty beds and silt-poor beds are sharp. The color of the disturbed structure shales varies from medium gray to dark gray or black.

The graded bedding shales are composed of beds that show obvious grading by decreasing grain size, decreasing number of grains, or a combination of both from the bottoms to the tops of the beds. The beds, or laminae, vary in thickness from approximately 1/4 inch to two inches and average about 1/2 inch. The bottoms of the beds or laminae are normally in sharp contact with the underlying layers. The color varies from medium gray to black.
The massive shales are very dark gray or black and are probably very closely related to the graded bedding shales but do not contain enough silt sized particles to make bedding easily visible.

Throughout much of the core the disturbed structure and graded bedding shales were so intimately associated that it was impractical to try to separate them. The rock type called "mixed disturbed structure and graded bedding shale" was established to include these intimate mixtures. The graded bedding shale seems to be the more dominant type in this mixed category.

The stratigraphic positions of the various rock types are shown in figure 4.

In order to make a microscopic examination of these rock types it was necessary to sample all the types in relatively small increments, i.e., chips or small hand specimens from which thin sections could be cut. The objectives of the thin section study were basically twofold; the first, to determine mineral composition of the rocks; the second, to determine their sorting and mean grain size.

To gain relevant information concerning the source area and the environment of deposition the sampling plan should be of a type such that an estimation can be made of the composition of the entire section representing the sedimentary body as well as the composition of each rock type. The samples (thin sections) should also give a reliable estimate of the grain size and sorting so that if the rocks differ in these properties the differences may be detected. In addition to showing the differences between rock types (which give a clue to the possibly differing environments of deposition) the data obtained should
show variations or differences within the rock types which would supply further information concerning the environment of deposition and its fluctuations within each type.

Further, the sampling method should be simple but of a type such that the information obtained will lend itself to a statistical analysis of the data. The method which fulfills all of these requirements is one of stratified, simple (and proportional) random samples of increments of approximately 22 x 33 mm, i.e., the size and thickness of a thin section. The strata were the 11 rock types. Samples within each rock type were taken randomly. The number of samples taken within each type was determined by the percentage of the entire core that the particular type composed. The basic plan was to take 100 samples so that if a rock type composed 24% of the total core 24 samples would be taken; however, three of the rock types were less than 1% of the total. A statistical comparison of these types would have been impossible with only one sample, therefore in these three cases two random samples were taken in each type, making a total of 103 samples for the entire core. The thin sections were ground to a thickness of approximately 0.025 mm and mounted in casdax which has an index of approximately 1.55.

MINERAL COMPOSITION

Mineral composition of the rocks was determined by the method of point counting in thin section as described by Milner (1962). On each slide 20 points were counted on each of five traverses. The lines were
randomly horizontal or vertical and direction of movement along the lines was also random. The starting point of each traverse was determined by dividing the thin section into coordinates and selecting one of these coordinates by use of a random number table. The purpose of this method of counting was to make each thin section as nearly a homogeneous sample of the rock type from which it was taken as was possible. Each of the 100 points thus located in the thin sections were designated as one of the categories described below.

**Quartz:** Attempts to divide the quartz grains into sub-types based on extinction were abandoned. Because of the generally small grain size the grains could not reliably be placed in categories of distinctive extinction patterns.

The grains were divided into two groups based on the relative number of inclusions present. If the grain contained five or more inclusions of any type in an area 0.01 mm in diameter it was called dusty quartz; otherwise it was called clear quartz. Subsequent statistical analysis indicated that the effect of grain size was so great that the division was of no value. A large grain was almost sure to have the required number of inclusions somewhere within its boundaries. The smaller the grain the less chance it had of containing the required number of inclusions.

Grain boundaries are commonly difficult to distinguish because of welding and cement. A few grains show secondary overgrowth and a very few of these showed rounding over the overgrowth. Quartz pebbles and large granules are usually composite grains. In several of these rock fragments original rounded quartz grains could be seen. More commonly
the rock fragments appear to be metaquartzite with original grain boundaries destroyed by suturing or welding to adjacent grains. Chert is present in minor amounts.

Illite (and other clay minerals): The clays were identified by X-ray diffraction. Samples of the shale were crushed and ground, then settled from water onto glass slides. Three slides of differing particle sizes were used for the X-ray identification. The particle sizes contained on the slides were determined by Stoke's law to be:
1 - less than 7.65 µ, 2 - less than 8 µ, and 3 - less than 8.65 µ. The X-ray peaks for illite were good. Peaks associated with kaolinite were only fair to poor. From this it was concluded that illite was the dominant clay mineral.

The differentiation of illite and sericite is difficult or impossible in thin sections. In this study only the grains smaller than 0.02 mm in length were called sericite or illite, as opposed to the larger grains called biotite or muscovite. If the birefringence did not exceed first order red they were arbitrarily called illite. If the birefringence did exceed first order red they were called sericite. Undoubtedly this method led to misidentification of one type for the other in an unknown number of cases. It can only be hoped that misidentification of sericite was balanced by the misidentification of illite.

The clay matrix is commonly mixed with varying amounts of carbonate (mostly siderite) and organic matter. In the shales the illite-siderite mixture is so intimate and fine grained that it was normally impossible to separate them and except in rare cases they were combined into a
single class.

**Siderite:** The siderite is a prominent yellowish brown, rarely clear yellow or colorless. In the sandstones siderite commonly occurs as a microcrystalline matrix forming a very effective cement. In both sandstones and shales it is mixed with illite.

**Muscovite and sericite:** Muscovite and sericite were differentiated on the basis of particle size. If the mica flake exceeded 0.02 mm in length it was called muscovite; if less than 0.02 mm in length it was called sericite.

**Calcite:** This mineral is relatively uncommon. It occurs as a cement and a very minor vein filler. It is also found replacing feldspar and mixed with the clay matrix.

**Feldspar:** All of the feldspars are very rare. As an aid to identifying some of the feldspars seventeen selected thin sections were stained with sodium cobaltinitrite in the manner described by Chayes (1952). This is a method of selective staining whereby the potash feldspars are stained a bright yellow and the other minerals are unaffected. By a slightly modified method one each of all the sandstone thin section rock chips and three silty shale chips were also stained. The chips were suspended, cut face down, 1/2 inch above liquid HF in a covered plastic dish for one minute. After removal, and without washing or drying, they were covered with a saturated solution of sodium cobaltinitrite for 15 minutes. The chips were then placed in a container of slowly flowing water for washing. All but five of the sandstone samples were returned from thin sectioning with two chips showing a flat cut face. This second group of chips was also stained by a somewhat
different method. Liquid HF was placed on the cut face and allowed to stand for one minute. The face was then covered with the same stain described above without washing the remaining HF from the surface. The stain was allowed to stand for 15 minutes and then the chip was washed as described above. Several control samples (known to contain potash feldspar) were carried through the complete staining process along with the sandstone chips. These control samples showed that the staining technique performed satisfactorily and consistently. The stain showed that potash feldspar is present in only very minor traces.

The orthoclase is almost completely altered to sericite, kaolin, or calcite. Microcline is the rarest of the feldspars and is the least altered. Plagioclase appears to be sodic and is commonly being replaced by sericite, kaolin, or calcite.

Rock fragments: Rock fragments are rare. Most of the fragments are either metaquartzite or orthoquartzite. Shale fragments occur in the sandstones and conglomerates. They are usually angular and are found near the base of the sandstone or conglomerate unit where it rests on a shale bed. The fragments identified as micaceous are probably very small shale fragments.

Pyrite: This mineral occurs as microcrystalline masses in the shales, possibly replacing both clays and carbonates. It also occurs in veins and coating joint surfaces in both the sandstones and shales.

Other accessory and heavy minerals: Five samples, four sandstones and one conglomerate, were crushed and all grains passing an 80 mesh screen were broken into heavy and light mineral fractions by standard bromoform separation as described by Milner (1962). The heavy mineral
concentrate was not cleaned with acid. Part of each heavy mineral concentrate was mounted on a slide in Canada balsam and the remaining grains were kept for study in various index liquids. This heavy mineral study was intended only to supplement the thin section study by identifying some of the more elusive grains.

Accessory or heavy minerals occurring in sufficient number to be picked up in the point count are leucoxene, zircon, limonite, magnetite (or magnetite-ilmenite), biotite, rutile, and garnet, in order of decreasing abundance.

Minerals identified in the thin sections or heavy mineral concentrates but not picked up in the point count are tourmaline, apatite, collophane (?), dahllite (?), hematite, halloysite (?), chalcedony, sphene (?), topaz, and staurolite, in approximate order of decreasing abundance.

The mineral composition of each rock type and the total core is given in Appendix B. The composition of each thin section is given in Appendix A.

GRAIN SIZE AND SORTING

Megascopic examination of the core resulted in two major structural classes, massive and bedded, with several subclasses, which have been described previously. These classes undoubtedly reflect the effect of grain size and sorting.

The megascopic divisions based on grain size and sorting, also discussed previously, are of course very broad in scope, the general classes being conglomerate, pebbly sands, sands, and shales. The more
subtle distinctions of classes and internal differences within the classes must be determined by a much more sensitive size analysis than can be afforded by a megascopic examination. The rocks, both shale and sandstone, were too much indurated to allow disaggregation of the grains for a mechanical analysis.

The solution was to measure the grains with the microscope and then compute average grain size and variances from these measurements. A great deal of work has been, and is being done in an effort to overcome the problems of size analyses and to make possible the comparison of mechanical analysis and direct measurement of both loose grains and grains in thin section. No attempt is made in this study to equate thin section size analysis with a mechanical analysis.

The size analysis is based on the measurement of the apparent long axes of quartz grains. The matrix has not been included in the analysis since the particles were too small to measure.

The apparent long axes of the quartz grains were measured with the graduated ocular in the microscope and these measurements were converted to $\phi$. The purpose of converting the measurements to $\phi$ was to normalize the grain size distribution, thereby simplifying statistical analyses. The grains to be measured must be randomly selected for an analysis. This random selection was accomplished by dividing the slide into coordinates and then selecting the coordinates at random by means of a random number table.

The number of grains to be measured per slide was determined by plotting the average grain size in $\phi$ against the number of grains measured for a series of grains in randomly selected slides. An example
of the graph used is shown in figure 5. When the mean grain size stabilized, i.e., no longer showed a wide fluctuation when additional grains were measured, the number measured was considered adequate. In the example shown the average grain size shows little variation after 16 grains had been measured. This was typical of the trial measurements. After a comparison of the charts it appeared that 18 grains would be sufficient to give a reliable estimate of the average grain size of any particular slide; however, two additional grains were measured in each slide as a safety factor, bringing the total number to 20 grains measured in each slide. From these data average grain size and variance were computed for each thin section, each rock type, and the total core. All of these data for thin sections are tabulated in Appendix A, and for rock types and the core totals in Appendix B.
Figure 5. Example of graphs used to determine the number of grains which should be measured in each thin section.
CHAPTER IV

ANALYSIS OF THE DATA

MINERAL COMPOSITION

The objectives of the analyses were to determine whether or not the rock types, based on megascopic observation, are truly different and if so, how they differ. The data and analyses can then be interpreted in terms of provenance and environment of deposition. All differences and interpretations have been based on the 95% level of confidence.

The first objective was to determine whether or not the rock types differ in mineral composition. To this end several standard chi-square tests were used.

A preliminary r x c contingency table was compiled of all 103 thin sections and the following seven classes: clear quartz, dusty quartz, siderite, illite, illite-siderite, all others with a specific gravity greater than 2.8 (heavy minerals), and all others with a specific gravity of 2.8 or less (light minerals). The size of this table (721 cells) makes its reproduction prohibitive and its preliminary character further makes its reproduction unnecessary. Chi-square tests from the table indicated that there was a difference between rock types but these differences were largely masked by completely random variations and interactions of several of the classes. An examination of
the data contained in this table and the data contained in tests of
association (discussed later) indicated that clear quartz is generally
found in small grains and dusty quartz in large grains. In view of
this the two classes were combined for future tests since the differ-
ences in quartz types between rocks would amount to differences only in
grain size which can best be tested directly. A further examination of
the individual cells and the rock type groups, sandstones and shales,
indicated that the three classes, illite, siderite, and illite-
siderite should be combined into one class. Since it had been possi-
ble to differentiate illite and siderite only in the coarse grained
rocks, while in most of the shales the illite and siderite had been
lumped into a single class, abnormally high chi-square values resulted
by confounding the mineral classes. The solution to the elimination of
these extraneous chi-square values was to combine all the illite and
siderite into one class for all r x c tables involving both the shales
and sandstones.

Some of the sources of variation not due strictly to true differ-
ences in mineral composition were eliminated by combining these classes
and it was possible to set up a much simpler chi-square test to
determine whether or not differences existed between rock types, and
whether or not these differences were of such a type or magnitude that
they could be detected with reasonable reliability. The total r x c
table was made up of 103 thin sections and four classes: all quartz,
all illite and siderite, all remaining light minerals, and all remain-
ing heavy minerals. This table was considered to be too large and not
necessary to include in its entirety. Table I is an r x c contingency
Table I. R x C Contingency Table of All 11 Rock Types Based on Four Compositional Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Rock Type 01 Massive Brown Sandstone</th>
<th>Rock Type 02 Bedded Brown Sandstone</th>
<th>Rock Type 03 Pebble Brown Sandstone</th>
<th>Rock Type 04 Massive Gray Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear and Dusty</td>
<td>0* = 1,968.00</td>
<td>0 = 159.00</td>
<td>0 = 362.00</td>
<td>0 = 1,376.00</td>
</tr>
<tr>
<td>Quartz</td>
<td>E** = 1,302.53</td>
<td>E = 108.54</td>
<td>E = 217.08</td>
<td>E = 922.62</td>
</tr>
<tr>
<td></td>
<td>(O-E) = 665.47</td>
<td>(O-E) = 50.46</td>
<td>(O-E) = 144.92</td>
<td>(O-E) = 453.38</td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 23.458740</td>
<td>(O-E)^2 = 96.746851</td>
<td>(O-E)^2 = 222.793159</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>0 = 219.00</td>
<td>0 = 17.00</td>
<td>0 = 18.00</td>
<td>0 = 181.00</td>
</tr>
<tr>
<td>(All)</td>
<td>E = 812.27</td>
<td>E = 67.69</td>
<td>E = 135.38</td>
<td>E = 575.36</td>
</tr>
<tr>
<td></td>
<td>(O-E) = -593.27</td>
<td>(O-E) = -50.69</td>
<td>(O-E) = -117.38</td>
<td>(O-E) = -394.36</td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 37.959464</td>
<td>(O-E)^2 = 101.773263</td>
<td>(O-E)^2 = 270.300002</td>
<td></td>
</tr>
<tr>
<td>Others (Heavies)</td>
<td>0 = 43.00</td>
<td>0 = 13.00</td>
<td>0 = 3.00</td>
<td>0 = 44.00</td>
</tr>
<tr>
<td></td>
<td>E = 108.58</td>
<td>E = 9.05</td>
<td>E = 18.10</td>
<td>E = 76.91</td>
</tr>
<tr>
<td></td>
<td>(O-E) = -65.58</td>
<td>(O-E) = 3.95</td>
<td>(O-E) = -15.10</td>
<td>(O-E) = -32.91</td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 39.608919</td>
<td>(O-E)^2 = 1.724033</td>
<td>(O-E)^2 = 12.667222</td>
<td>(O-E)^2 = 14.082279</td>
</tr>
<tr>
<td>Others (Lights)</td>
<td>0 = 170.00</td>
<td>0 = 11.00</td>
<td>0 = 17.00</td>
<td>0 = 99.00</td>
</tr>
<tr>
<td></td>
<td>E = 176.62</td>
<td>E = 14.72</td>
<td>E = 29.44</td>
<td>E = 125.11</td>
</tr>
<tr>
<td></td>
<td>(O-E) = -6.62</td>
<td>(O-E) = -3.72</td>
<td>(O-E) = -12.44</td>
<td>(O-E) = -26.11</td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 0.248128</td>
<td>(O-E)^2 = 0.940109</td>
<td>(O-E)^2 = 5.256576</td>
<td>(O-E)^2 = 5.449062</td>
</tr>
<tr>
<td>Total</td>
<td>0 = 2,400</td>
<td>0 = 200</td>
<td>0 = 400</td>
<td>0 = 1,700</td>
</tr>
</tbody>
</table>

*Observed value  
**Expected value
Table I. (Continued) H x C Contingency Table of all 11 Rock Types Based on Four Compositional Classes

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Rock Type 05 Bedded Gray Sandstone</th>
<th>Rock Type 06 Pebbly Gray Sandstone</th>
<th>Rock Type 07 Conglomerate</th>
<th>Rock Type 08 Massive Shale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
<td>0* = 583.00</td>
<td>0 = 131.00</td>
<td>0 = 193.00</td>
<td>0 = 26.00</td>
</tr>
<tr>
<td>Clear and Dusty Quartz</td>
<td>E** = 542.72</td>
<td>E = 108.54</td>
<td>E = 108.54</td>
<td>E = 108.54</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E) = 22.46</td>
<td>(O-E) = 84.46</td>
<td>(O-E) = 84.46</td>
<td>(O-E) = -82.54</td>
</tr>
<tr>
<td>Illite-Siderite (All)</td>
<td>E = 191.00</td>
<td>E = 59.00</td>
<td>E = 1.00</td>
<td>E = 154.00</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E) = -6.69</td>
<td>(O-E) = -86.69</td>
<td>(O-E) = -86.69</td>
<td>(O-E) = 86.31</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E)**2 = 64.238447</td>
<td>(O-E)**2 = 1.115617</td>
<td>(O-E)**2 = 110.051944</td>
<td>110.051944</td>
</tr>
<tr>
<td>Others (Heavies)</td>
<td>E = 77.00</td>
<td>E = 5.00</td>
<td>E = 0.00</td>
<td>E = 6.00</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E) = 2.989531</td>
<td>(O-E) = 9.05</td>
<td>(O-E) = 9.05</td>
<td>(O-E) = 9.05</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E)**2 = 22.296587</td>
<td>(O-E)**2 = 1.812431</td>
<td>(O-E)**2 = 1.027901</td>
<td>1.027901</td>
</tr>
<tr>
<td>Others (Lights)</td>
<td>E = 149.00</td>
<td>E = 77.275012</td>
<td>E = 6.00</td>
<td>E = 14.00</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E) = 73.59</td>
<td>(O-E) = 77.275012</td>
<td>(O-E) = 14.72</td>
<td>(O-E) = 14.72</td>
</tr>
<tr>
<td><strong>(O-E)</strong></td>
<td>(O-E)**2 = 75.41</td>
<td>(O-E)**2 = 6.418370</td>
<td>(O-E)**2 = 5.165652</td>
<td>(O-E)**2 = 0.035217</td>
</tr>
<tr>
<td>Total</td>
<td>1,000</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

*Observed value
**Expected value
Table I. (Continued) R x C Contingency Table of All 11 Rock Types Based on Four Compositional Classes

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Rock Type 09</th>
<th>Rock Type 10</th>
<th>Rock Type 11</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Disturbed Structure Shale</td>
<td>Graded Bedding Shale</td>
<td>Mixed Disturbed Structure and Graded Bedding Shale</td>
<td></td>
</tr>
<tr>
<td>Clear and Dusty Quartz</td>
<td>(O-E) = 596.99</td>
<td>(O-E) = 265.324444</td>
<td>(O-E) = 199.00</td>
<td>(O-E) = 328.00</td>
</tr>
<tr>
<td></td>
<td>(O-E)² = 184.621736</td>
<td>(O-E)² = 265.324444</td>
<td>(O-E)² = 431.036828</td>
<td>(O-E)² = 1,700.101720</td>
</tr>
<tr>
<td>Illite-Siderite (All)</td>
<td>(O-E) = 657.00</td>
<td>(O-E) = 792.00</td>
<td>(O-E) = 1,197.00</td>
<td>(O-E) = 3,486.00</td>
</tr>
<tr>
<td></td>
<td>(O-E)² = 284.71</td>
<td>(O-E)² = 473.170066</td>
<td>(O-E)² = 567.151739</td>
<td>(O-E)² = 2,342.513860</td>
</tr>
<tr>
<td>Others (Heavies)</td>
<td>(O-E) = 100.00</td>
<td>(O-E) = 47.00</td>
<td>(O-E) = 128.00</td>
<td>(O-E) = 466.00</td>
</tr>
<tr>
<td></td>
<td>(O-E)² = 50.23</td>
<td>(O-E)² = 0.154167</td>
<td>(O-E)² = 26.633488</td>
<td>(O-E)² = 179.751279</td>
</tr>
<tr>
<td>Others (Lights)</td>
<td>(O-E) = 78.00</td>
<td>(O-E) = 62.00</td>
<td>(O-E) = 147.00</td>
<td>(O-E) = 758.00</td>
</tr>
<tr>
<td></td>
<td>(O-E)² = 80.95</td>
<td>(O-E)² = -18.95</td>
<td>(O-E)² = -13.95</td>
<td>(O-E)² = -2.95</td>
</tr>
<tr>
<td></td>
<td>(O-E)² = 0.107505</td>
<td>(O-E)² = 4.436103</td>
<td>(O-E)² = 1.596041</td>
<td>(O-E)² = 106.927775</td>
</tr>
<tr>
<td>Total</td>
<td>1,100.00</td>
<td>1,100.00</td>
<td>1,800.00</td>
<td>10,300.00</td>
</tr>
</tbody>
</table>

*Observed value
**Expected value
table for the 11 rock types presented for comparison of the chi-square values of the rock types and classes within rock types. Only the total chi-square values for each class and for the total table are given in table II, which also contains the chi-square values for rock types and for thin sections within rock types, plus an F test of chi-square of rock types vs. chi-square of thin sections within rock types.

A comparison of the calculated chi-square values with tabulated chi-square values at the 95% confidence level shows that, at this level of confidence, there are significant differences between thin sections within the core ($\chi^2_T$), between rock types ($\chi^2_{RT}$), and thin sections within rock types ($\chi^2_{S/RT}$). The F test shows that at the 95% confidence level $\chi^2_{RT}$ is significantly greater than $\chi^2_{S/RT}$; therefore there are differences in composition between rock types which can be detected by the methods used in this study.

These tests established the fact that the rock types could be distinguished on the basis of composition. The next step was to determine whether or not the major portion of these differences was arising from the differences between the sandstones and shales as the cell values in Table I seem to indicate. For this test (shown in table III) the same compositional classes were used as in the previous test. The resulting chi-square values for rock types, for groups (sandstone and shale), and for rock types within groups are all significant at the 95% level but the F test shows that at the 95% confidence level the differences between groups are significantly greater than the differences within groups. This shows that the sandstones are different in composition from the shales. It also indicates that the differentiation of the
Table II. Chi-Square Values and F Test of All 11 Rock Types
Based on Four Compositional Classes

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>( \chi^2 ) Total (( \chi^2_T ))</th>
<th>( \chi^2 ) Rock Type (( \chi^2_{RT} ))</th>
<th>( \chi^2 ) Thin Section/Rock Type (( \chi^2_{S/RT} = \chi^2_T - \chi^2_{RT} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear and Dusty Quartz</td>
<td>1,798.311934</td>
<td>1,700.101720</td>
<td>98.210214</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>2,597.899483</td>
<td>2,342.513860</td>
<td>255.385623</td>
</tr>
<tr>
<td>Others (Heavies)</td>
<td>450.374159</td>
<td>179.751279</td>
<td>270.622880</td>
</tr>
<tr>
<td>Others (Lights)</td>
<td>255.938695</td>
<td>106.927775</td>
<td>149.010920</td>
</tr>
</tbody>
</table>

\[ \chi^2_T = \chi^2_{S/RT} + \chi^2_{RT} \]

\[ \chi^2_{S/RT} = \chi^2_T - \chi^2_{RT} \]

\( \frac{\chi^2_{RT}}{\chi^2_{S/RT}} = \frac{4,329.295/30}{773.230/276} = 51.502 \)

*Significant at 95% level of confidence.
Table III. Chi-Square Values and F Test of Sandstones vs. Shales
Based on Four Compositional Classes

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Clear and Dusty Quartz</th>
<th>Illite-Siderite</th>
<th>Others (Heavies)</th>
<th>Others (Lights)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock Type</td>
<td>$X^2_T = X^2$ by</td>
<td>$X^2_T = X^2$ by</td>
<td>$X^2_T = X^2$ by</td>
<td>$X^2_T = X^2$ by</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$X^2_G$ = All Sandstones and Conglomerate vs. All Shales</td>
<td>$X^2_G$ = All Sandstones and Conglomerate vs. All Shales</td>
<td>$X^2_G$ = All Sandstones and Conglomerate vs. All Shales</td>
<td>$X^2_G$ = All Sandstones and Conglomerate vs. All Shales</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$X^2_{RT/G} = X^2_T - X^2_G$</td>
<td>$X^2_{RT/G} = X^2_T - X^2_G$</td>
<td>$X^2_{RT/G} = X^2_T - X^2_G$</td>
<td>$X^2_{RT/G} = X^2_T - X^2_G$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clear and Dusty Quartz</td>
<td>Illite-Siderite</td>
<td>Others (Heavies)</td>
<td>Others (Lights)</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>$1,700.101720$</td>
<td>$2,342.513860$</td>
<td>$179.751279$</td>
<td>$106.927775$</td>
<td>$4,329.294634$</td>
</tr>
<tr>
<td></td>
<td>$-1,582.098285$</td>
<td>$2,257.360542$</td>
<td>$73.553575$</td>
<td>$0.357549$</td>
<td>$3,913.369451$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$415.925183$</td>
</tr>
</tbody>
</table>

W/30 degrees of freedom

Calculated $F^* = \frac{\chi^2_G}{\chi^2_{RT/G}} = \frac{3,913.369/3}{415.925/27} = 84.677$

*Significant at 95% level of confidence.
bedded sandstones and disturbed structure shales, based on bedding thickness, as discussed earlier, was operationally and statistically satisfactory, for otherwise the differences within groups might have been equal to or greater than the differences between groups.

The division of the sandstones into two groups based on color implied a difference in composition. Examination of thin section data indicated that if a difference in composition existed it should be either in the percentage of siderite, the percentage of illite, or a combination of both minerals contained in the two groups, since the brown sandstones seemed to be relatively high in siderite and the gray sandstones relatively high in illite. Examination of the thin sections and sandstone rock types also indicated that whether or not the differences between the two groups were due to illite or siderite content the type called pebbly gray sandstone actually belonged in the brown sandstone group since it had the highest percentage of siderite of all the rock types and a very low percentage of illite. Table IV is an r x c contingency table of the sandstone rock types (exclusive of conglomerate). An examination of this table, which is based on siderite content vs. all others, shows that the massive gray and bedded gray sandstones are relatively low in siderite content. This indicates that the group containing rock types 01, 02, 03, and 06 may be distinguished from the group containing rock types 04 and 05. Table V contains the chi-square values and F test for the sandstones based on siderite vs. all others. The chi-square values for total rock types, groups, and rock types within groups all indicate that significant differences exist; however, the F test indicates that the differences between the brown and gray sandstone groups are no greater than the
Table IV. R x C Contingency Table of the Sandstones Based on Siderite vs. All Others

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Rock Type 01 Massive Brown Sandstone</th>
<th>Rock Type 02 Bedded Brown Sandstone</th>
<th>Rock Type 03 Pebby Brown Sandstone</th>
<th>Rock Type 04 Massive Gray Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>O* = 171.00</td>
<td>0 = 12.00</td>
<td>0 = 16.00</td>
<td>0 = 10.00</td>
</tr>
<tr>
<td></td>
<td>E** = 114.71</td>
<td>E = 9.56</td>
<td>E = 19.12</td>
<td>E = 81.25</td>
</tr>
<tr>
<td>Siderite</td>
<td>(O-E) = 56.29</td>
<td>(O-E) = 2.44</td>
<td>(O-E) = -3.12</td>
<td>(O-E) = -71.25</td>
</tr>
<tr>
<td></td>
<td>( \frac{(O-E)^2}{E} = 27.622338 )</td>
<td>( \frac{(O-E)^2}{E} = 0.622762 )</td>
<td>( \frac{(O-E)^2}{E} = 0.509121 )</td>
<td>( \frac{(O-E)^2}{E} = 62.480769 )</td>
</tr>
<tr>
<td>All Others</td>
<td>O = 2,229.00</td>
<td>O = 188.00</td>
<td>O = 384.00</td>
<td>O = -1,690.00</td>
</tr>
<tr>
<td></td>
<td>E = 2,285.29</td>
<td>E = 190.44</td>
<td>E = 380.88</td>
<td>E = -1,618.75</td>
</tr>
<tr>
<td></td>
<td>(O-E) = -56.29</td>
<td>(O-E) = -2.44</td>
<td>(O-E) = 3.12</td>
<td>(O-E) = 71.25</td>
</tr>
<tr>
<td></td>
<td>( \frac{(O-E)^2}{E} = 1.386504 )</td>
<td>( \frac{(O-E)^2}{E} = 0.031262 )</td>
<td>( \frac{(O-E)^2}{E} = 0.025558 )</td>
<td>( \frac{(O-E)^2}{E} = 3.136100 )</td>
</tr>
</tbody>
</table>

Total 2,400 200 400 1,700

*Observed value.
**Expected value.
Table IV. (Continued) R x C Contingency Table of the Sandstones Based on Siderite vs. All Others

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Type Class</th>
<th>Rock Type 05 Bedded Grey Sandstone</th>
<th>Rock Type 06 Pebbly Grey Sandstone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siderite</td>
<td>0*</td>
<td>21.00</td>
<td>0</td>
<td>52.00</td>
</tr>
<tr>
<td></td>
<td>E**</td>
<td>47.80</td>
<td>E</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>(0-E)</td>
<td>-26.80</td>
<td>(0-E)</td>
<td>42.44</td>
</tr>
<tr>
<td></td>
<td>(0-E)^2/E</td>
<td>15.025941</td>
<td>(0-E)^2/E</td>
<td>188.405188</td>
</tr>
</tbody>
</table>

| All Others | 0         | 979.00                            | 0                                 | 143.00 | 0 | 5,618 |
|            | E         | 952.20                            | E                                 | 190.44 | 0 |       |
|            | (0-E)     | 26.80                             | (0-E)                             | -42.44 | 0 |       |
|            | (0-E)^2/E | 0.754295                         | (0-E)^2/E                         | 9.457853 | (0-E)^2 | 14.791573 |

| Total      | 1,000     | 200                               | 0                                 | 5,900 | (0-E)^2 | 309.457742 |

*Observed value.
**Expected value.
### Table V. Chi-Square Values and F Test of the Sandstones Based on Siderite vs. All Others

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>( \chi^2_T = \chi^2 ) by Rock Type vs. Groups</th>
<th>( \chi^2 ) Groups 01, 02, 03, &amp; 06</th>
<th>( \chi^2 ) Rock Types/Groups 04 &amp; 05</th>
<th>( \chi^2_{RTG} = \chi^2_T - \chi^2_G )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siderite</td>
<td>294.666169</td>
<td>137.352578</td>
<td>157.313591</td>
<td></td>
</tr>
<tr>
<td>All Others</td>
<td>14.791573</td>
<td>6.894515</td>
<td>7.897058</td>
<td></td>
</tr>
</tbody>
</table>

**Calculated F** = \( \frac{\chi^2_G}{\chi^2_{RTG}} \) = \( \frac{144.247/1}{165.211/4} \) = 3.492

*Significant at 95% level of confidence*
differences within the groups. Therefore the two groups cannot be differentiated on the basis of siderite content with the methods employed in this study.

The possibility that the brown and gray sandstone groups could be differentiated on the basis of illite content was the subject of the next test. Table VI is an r x c contingency table of the sandstones based on illite vs. all others. As in the previous test the conglomerate is excluded since it is considered to be a rock type of sufficient distinction that it can be differentiated without resorting to differences in composition. A comparison of the observed and expected values of illite shown in this table indicates that types 01, 02, 03, and 06 should be placed in one group, and the massive gray sandstones (04) and bedded gray sandstones (05), which are high in illite, should be placed in another. Table VII contains the chi-square values and F test for the sandstones based on illite vs. all others. As in the test for siderite the values are significant for total rock types, groups, and rock types within groups indicating that significant differences exist at all three levels. The F test indicates, however, that the differences between groups are significantly greater than the differences within groups, therefore the two groups can be distinguished on the basis of illite content.

Apparently the color of the brown sandstones is due to the presence of the siderite, but where illite is present in sufficient quantity, as it is in the gray sandstones, the brown color is masked by the clay. The pebbly gray sandstone, which has been shown above to belong in the brown sandstone group, was incorrectly classified at the megascopic level because the siderite was either exceptionally dark or was present
Table VI. R x C Contingency Table of the Sandstones Based on Illite vs. All Others

<table>
<thead>
<tr>
<th>Class</th>
<th>Rock Type 01 Massive Brown Sandstone</th>
<th>Rock Type 02 Bedded Brown Sandstone</th>
<th>Rock Type 03 Pebbly Brown Sandstone</th>
<th>Rock Type 04 Massive Gray Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illite</td>
<td>0* = 48.00</td>
<td>0 = 5.00</td>
<td>0 = 2.00</td>
<td>0 = 171.00</td>
</tr>
<tr>
<td></td>
<td>E** = 163.93</td>
<td>E = 13.66</td>
<td>E = 27.32</td>
<td>E = 116.12</td>
</tr>
<tr>
<td></td>
<td>(0-E) = -115.93</td>
<td>(0-E) = -8.66</td>
<td>(0-E) = -25.32</td>
<td>(0-E) = 54.88</td>
</tr>
<tr>
<td></td>
<td>(0-E)^2 = 81.984779</td>
<td>(0-E)^2 = 5.490161</td>
<td>(0-E)^2 = 23.466413</td>
<td>(0-E)^2 = 25.937086</td>
</tr>
<tr>
<td></td>
<td>E = 2,352.00</td>
<td>E = 195.00</td>
<td>E = 398.00</td>
<td>E = 1,529.00</td>
</tr>
<tr>
<td></td>
<td>(0-E) = 115.93</td>
<td>(0-E) = 8.66</td>
<td>(0-E) = 25.32</td>
<td>(0-E) = -54.88</td>
</tr>
<tr>
<td></td>
<td>(0-E)^2 = 6.010440</td>
<td>(0-E)^2 = 0.402466</td>
<td>(0-E)^2 = 1.720249</td>
<td>(0-E)^2 = 1.901542</td>
</tr>
<tr>
<td>Total</td>
<td>2,400</td>
<td>200</td>
<td>400</td>
<td>1,700</td>
</tr>
</tbody>
</table>

*Observed value.
**Expected value.
Table VI. (Continued) R x C Contingency Table of the Sandstones Based on Illite vs. All Others

<table>
<thead>
<tr>
<th>Class</th>
<th>Rock Type 05 Bedded Gray Sandstone</th>
<th>Rock Type 06 Pebble Gray Sandstone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illite</td>
<td>0* = 170.00</td>
<td>0 = 7.00</td>
<td>0 = 403</td>
</tr>
<tr>
<td></td>
<td>E** = 68.31</td>
<td>E = 13.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(O-E) = 101.69</td>
<td>(O-E) = -6.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 151.381292</td>
<td>(O-E)^2 = 3.247116</td>
<td>(O-E)^2 = 291.506847</td>
</tr>
<tr>
<td>All Others</td>
<td>0 = 830.00</td>
<td>0 = 193.00</td>
<td>0 = 5,497</td>
</tr>
<tr>
<td></td>
<td>E = 931.69</td>
<td>E = 186.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(O-E) = -101.69</td>
<td>(O-E) = 6.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(O-E)^2 = 11.099031</td>
<td>(O-E)^2 = 0.238036</td>
<td>(O-E)^2 = 21.371764</td>
</tr>
<tr>
<td>Total</td>
<td>1,000</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 = 5,900</td>
<td>(O-E)^2 = 312.878611</td>
<td></td>
</tr>
</tbody>
</table>

*Observed value.
**Expected value.
Table VII. Chi-Square Values and F Test of the Sandstones Based on Illite vs. All Others

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>(\chi^2_T) = (\chi^2) by Rock Type</th>
<th>(\chi^2_G) = Groups 01, 02, 03, &amp; 06 vs. 04 &amp; 05</th>
<th>(\chi^2) Rock Type/Groups = (\chi^2_{RT/G}) = (\chi^2_T - \chi^2_G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>291.506847</td>
<td>245.108958</td>
<td>46.397889</td>
</tr>
<tr>
<td>All Others</td>
<td>21.371764</td>
<td>17.969542</td>
<td>3.402222</td>
</tr>
<tr>
<td>Total</td>
<td>(\chi^2_T) = 312.878611</td>
<td>(\chi^2_G) = 263.078500</td>
<td>(\chi^2_{RT/G}) = 49.800111</td>
</tr>
<tr>
<td></td>
<td>(W/5) degrees of freedom</td>
<td>(W/1) degree of freedom</td>
<td>(W/4) degrees of freedom</td>
</tr>
<tr>
<td>Calculated F*</td>
<td>(\chi^2_G)</td>
<td>(\chi^2_{RT/G}) = 263.079/1</td>
<td>(\chi^2_{RT/G}) = 49.800/4</td>
</tr>
</tbody>
</table>

\*Significant at 95\% level of confidence.
in a sufficient concentration that the brown color was too dark to recognize the brown tone and the rock was erroneously classed as very dark gray.

A final chi-square test appeared desirable when a comparison of average quartz grain size and illite content was made. It was suspected that quartz grain size and illite content might be related. Table VII is a 2 x 2 chi-square test for association of quartz grain size with illite content. A coefficient of association value is represented by \( \psi \).

The chi-square value indicates that there is a significant relationship between average quartz grain size and illite content. An examination of the individual cells shows that as average quartz grain size increases illite content decreases. The coefficient of association shown by the \( \psi \) value is 0.85, indicating that the association of increasing grain size with decreasing illite content is a relatively strong one. If this is the case then the difference between the brown and gray sandstone groups may be largely due to grain size with a resulting change in composition, or, more specifically, the differences may be due to changes in the energy system at or near the site of deposition.

Tests for the association of illite and grain sorting, sorting and average grain size, and quartz and illite content, supplied no new information concerning the sandstones or shales and the results of this testing are not included.

In summary, chi-square tests indicate that the rock types and groups can be distinguished on the basis of differences in composition
Table VIII. 2 x 2 Chi-Square and Q Test of Association of Quartz Grain Size and Illite Content

<table>
<thead>
<tr>
<th>Categories</th>
<th>0 - 4% Illite</th>
<th>4 - 26% Illite</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.73 to 2.40 ( \bar{\theta} )</td>
<td>( \bar{\theta} = 23 )</td>
<td>( \bar{\theta} = 6 )</td>
<td>29</td>
</tr>
<tr>
<td>( (0-\bar{\theta}) )</td>
<td>( 14.7 )</td>
<td>( 14.3 )</td>
<td></td>
</tr>
<tr>
<td>( (\bar{\theta} - E)^2 )</td>
<td>( 8.3 )</td>
<td>( 4.686 )</td>
<td>( 4.817 )</td>
</tr>
<tr>
<td>2.46 to 4.83 ( \bar{\theta} )</td>
<td>( \bar{\theta} = 7 )</td>
<td>( \bar{\theta} = 23 )</td>
<td>30</td>
</tr>
<tr>
<td>( (0-\bar{\theta}) )</td>
<td>( -8.3 )</td>
<td>( 8.3 )</td>
<td></td>
</tr>
<tr>
<td>( (\bar{\theta} - E)^2 )</td>
<td>( 4.503 )</td>
<td>( 4.686 )</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>29</td>
<td>59</td>
</tr>
</tbody>
</table>

\( \chi^2 = \text{Total } \frac{(0-\bar{\theta})^2}{E} = 18.692 \)

W/1 degree of freedom and is significant at the 95% confidence level.

\( Q = \frac{(23)(23) - (6)(7)}{(23)(23) + (6)(7)} = 0.8529 \)

Conclusion: As mean grain size decreases illite content increases. The Q value indicates that this association is a relatively strong one.
and that the original types determined by megascopic differences are valid with the exception of the type called "pebbly gray sandstone." This type was found to belong to the brown sandstone group. The differences in mineral composition of the brown sandstones and gray sandstones were found to be directly related to average quartz grain size; therefore these two groups can probably be differentiated on the basis of grain size alone.

GRAIN SIZE, SORTING AND STRUCTURE

Many statisticians feel that before an analysis of variance, which detects differences in mean size, can be satisfactorily performed it is necessary that the populations be normally distributed and that the variances of the populations be homogeneous. In this study the grain size distribution, based on measurements of the apparent long axes, has been normalized by converting the measurements from millimeters to $\phi$ where $\phi = -\log_2 \text{mm}$ (Krumbein and Pettijohn, 1938). That the variances of grain sizes of sedimentary units are homogeneous is certainly open to doubt. A Bartlett's test for homogeneity of variance (Ostle, 1958) should be and was made in this case.

Table IX is a Bartlett's test made on the entire core. The results indicate that the variances of the thin sections are not homogeneous, i.e., variances are heterogeneous between thin sections. This precludes tests by analysis of variance, but the information gained from the test can be of great value.

The knowledge that differences in mean grain size exist between sedimentary rock units is normally of no greater importance than an
<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Uppercase</th>
<th>Lowercase</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table IX. Bartlett’s Test of Thin Sections Within the Latter Core

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Uppercase</th>
<th>Lowercase</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample Size of Freedom

Sample Size of Freedom

Table IX. Bartlett’s Test of Thin Sections Within the Latter Core
<table>
<thead>
<tr>
<th>Sample</th>
<th>df</th>
<th>Freedom of d.f.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For the complete table, refer to the contained (continued) section of the document within the text.
Table IX. (Continued) Bartlett's Test of Thin Sections Within the Entire Core

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sum $y^2$</th>
<th>Degrees of Freedom</th>
<th>$\frac{1}{d.f.}$</th>
<th>$s^2$</th>
<th>$\log_{10}s^2$</th>
<th>(d.f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/02</td>
<td>13.5431</td>
<td>19</td>
<td>0.0526</td>
<td>.7128</td>
<td>-1.470</td>
<td>-2.7937</td>
</tr>
<tr>
<td>11/03</td>
<td>9.1885</td>
<td>19</td>
<td>0.0526</td>
<td>.4836</td>
<td>-3.155</td>
<td>-5.9947</td>
</tr>
<tr>
<td>11/04</td>
<td>5.0551</td>
<td>19</td>
<td>0.0526</td>
<td>.2661</td>
<td>-5.750</td>
<td>-10.9255</td>
</tr>
<tr>
<td>11/05</td>
<td>3.2919</td>
<td>19</td>
<td>0.0526</td>
<td>.1733</td>
<td>-7.613</td>
<td>-14.4647</td>
</tr>
<tr>
<td>11/06</td>
<td>9.3968</td>
<td>19</td>
<td>0.0526</td>
<td>.4946</td>
<td>-3.058</td>
<td>-5.8097</td>
</tr>
<tr>
<td>11/07</td>
<td>6.3179</td>
<td>19</td>
<td>0.0526</td>
<td>.3325</td>
<td>-4.782</td>
<td>-9.0854</td>
</tr>
<tr>
<td>11/08</td>
<td>4.7219</td>
<td>19</td>
<td>0.0526</td>
<td>.2485</td>
<td>-5.6046</td>
<td>-11.4881</td>
</tr>
<tr>
<td>11/09</td>
<td>3.2350</td>
<td>19</td>
<td>0.0526</td>
<td>.1703</td>
<td>-7.689</td>
<td>-14.6088</td>
</tr>
<tr>
<td>11/10</td>
<td>6.2967</td>
<td>19</td>
<td>0.0526</td>
<td>.3314</td>
<td>-4.796</td>
<td>-9.1131</td>
</tr>
<tr>
<td>11/11</td>
<td>4.6463</td>
<td>19</td>
<td>0.0526</td>
<td>.2445</td>
<td>-6.116</td>
<td>-11.6212</td>
</tr>
<tr>
<td>11/12</td>
<td>3.1906</td>
<td>19</td>
<td>0.0526</td>
<td>.1679</td>
<td>-7.774</td>
<td>-14.7228</td>
</tr>
<tr>
<td>11/13</td>
<td>4.8755</td>
<td>19</td>
<td>0.0526</td>
<td>.2566</td>
<td>-5.907</td>
<td>-11.2240</td>
</tr>
<tr>
<td>11/14</td>
<td>7.2642</td>
<td>19</td>
<td>0.0526</td>
<td>.3823</td>
<td>-4.176</td>
<td>-7.9337</td>
</tr>
<tr>
<td>11/15</td>
<td>4.5127</td>
<td>19</td>
<td>0.0526</td>
<td>.2391</td>
<td>-6.214</td>
<td>-11.8074</td>
</tr>
<tr>
<td>11/16</td>
<td>8.8653</td>
<td>19</td>
<td>0.0526</td>
<td>.4666</td>
<td>-3.311</td>
<td>-6.2901</td>
</tr>
<tr>
<td>11/17</td>
<td>7.3139</td>
<td>19</td>
<td>0.0526</td>
<td>.3849</td>
<td>-4.146</td>
<td>-7.8774</td>
</tr>
<tr>
<td>11/18</td>
<td>3.7786</td>
<td>19</td>
<td>0.0526</td>
<td>.1989</td>
<td>-7.014</td>
<td>-13.3270</td>
</tr>
<tr>
<td>Total</td>
<td>1,124.6763</td>
<td>1957</td>
<td></td>
<td>5.4173</td>
<td></td>
<td>-661.0870</td>
</tr>
</tbody>
</table>

$s^2 = \frac{1124.6763}{1957} = 0.574694$

$B = (\log_{10}s^2) \text{ d.f. Total} = -0.240565 \ (1957) = -470.782$

$X^2 = \log_{10} 10 \left[ B - \text{Total d.f. } \log_{10}s^2 \right]$

$X^2 = 2.3026 \left[ -470.782 - (-661.087) \right] = 438.191$

Correction factor =

$C = 1 + \left[ \frac{1}{3(\text{thin section } -1)} \right] \left[ \frac{1}{\text{d.f. Total} - \frac{1}{(n-1) \text{Total}}} \right]$

$C = 1 + \left[ \frac{1}{3(192)} \right] \left[ 5.4178 - \frac{1}{1957} \right] = 1.0177114$

Corrected $X^2 = \frac{438.191}{1.0177114} = 430.564$ with 102 degrees of freedom

Corrected $X^2$ is significant at the 95% confidence level

Conclusion: The variance between thin sections is not homogeneous.
understanding of how well the grains have been sorted. An estimate of
the variance of a population is an estimate of how widely the individ­
uals of the population are scattered around the population average.
More specifically an estimate of the variance of the grain size of a
rock unit is an estimate of the sorting of the grains. The Bartlett’s
test in Table IX has actually indicated that there are differences
between thin sections in the degree of sorting of the grains. This
information suggested that there might be differences in the degree of
sorting between rock types.

A separate Bartlett’s test was made on each rock type to determine
if the differences in variance were entirely due to differences between
rock types. If the differences were due only to differences between
rock types the variance between thin sections within each rock type
should be homogeneous. Table X contains the results of these 11 tests.
The three rock types, massive brown sandstone, massive gray sandstone,
and mixed disturbed structure and graded bedding shale, have hetero­
genous variances between thin sections. The remaining eight rock
types have homogeneous variances between thin sections.

In order better to understand these results the mean grain size
and variance of each rock type has been plotted in figure 6 so that a
comparison of differences between types can be made. The implications
and interpretations are discussed in the following sections.

Differences between rock types.

A comparison of the rock types by average grain size and sorting
as plotted in figure 6 shows a wide range of differences of grain size
and sorting between rock types. These types may be best understood in
Table X. Results of Bartlett's Tests on Thin Sections Within Each Rock Type

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Corrected $\chi^2$</th>
<th>Degrees of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive Brown Sandstone (01)</td>
<td>59.3820*</td>
<td>23</td>
</tr>
<tr>
<td>Bedded Brown Sandstone (02)</td>
<td>.6605</td>
<td>1</td>
</tr>
<tr>
<td>Pebbly Brown Sandstone (03)</td>
<td>1.4813</td>
<td>3</td>
</tr>
<tr>
<td>Massive Gray Sandstone (04)</td>
<td>54.0656*</td>
<td>16</td>
</tr>
<tr>
<td>Bedded Gray Sandstone (05)</td>
<td>14.6659</td>
<td>9</td>
</tr>
<tr>
<td>Pebbly Gray Sandstone (06)</td>
<td>.2867</td>
<td>1</td>
</tr>
<tr>
<td>Conglomerate (07)</td>
<td>1.1942</td>
<td>1</td>
</tr>
<tr>
<td>Massive Shale (08)</td>
<td>.4442</td>
<td>1</td>
</tr>
<tr>
<td>Disturbed Structure Shale (09)</td>
<td>17.1750</td>
<td>10</td>
</tr>
<tr>
<td>Graded Bedding Shale (10)</td>
<td>7.0745</td>
<td>10</td>
</tr>
<tr>
<td>Mixed Disturbed Structure and Graded Bedding Shale (11)</td>
<td>60.8521*</td>
<td>17</td>
</tr>
</tbody>
</table>

*Significant at the 95% level of confidence. The variance between thin sections within these rock types is not homogeneous.
Figure 6. Comparison of the average grain size and variance of the 11 rock types and the entire cored section used in the study.
terms of the energy system from which they were deposited. Other things being equal, the extent to which a sediment is well sorted is dependent on the efficiency or duration of the energy acting on the sedimentary system. Sorting would be expected to improve with increasing energy efficiency or duration. Other factors which may influence sorting are the sizes of particles available for deposition, the distance traveled from the source area, and the specific gravity of the particles being acted upon. Other things being equal, grain size is a function of the intensity of the energy acting on the sedimentary system. Grain size would be expected to increase with increasing energy intensity. As is the case in sorting, distance traveled from the source area, size of the particles available, and specific gravity are factors which may influence the average grain size of the sedimentary unit.

In order to define the rock types in terms of energy systems it is necessary to account for the other factors influencing grain size and sorting as far as possible. The effect of differing specific gravities on particle size and sorting is absent since only quartz grains were measured. It is not so easy to account for the possible effects of the particle sizes available on the average grain size and sorting but it seems logical to assume that the source area was not exceptionally coarse grained since the conglomerates contained in the study section are small-pebble conglomerates. At any rate, a discussion of energy systems represented by sedimentary units can be applied only to relative duration or intensities and the conglomerate contained in the cores can be considered to represent the environment of maximum energy intensity relative to the other rock types. The effect of distance
traveled from the source area is unknown and cannot be reliably accounted for in this study. This effect may be negligible in the sediments being studied. The close association of relatively fine with relatively coarse grained sediments which do not show evidence of being turbidites is much easier to explain by a change in the energy system than by a change in the distance from the source area. Having thus made an attempt to account for factors other than the energy system at the site of deposition, this paper will attempt to interpret the rock types on the basis of varying energy systems; however, the possibility of other effects should be kept in mind at all times.

When the sorting and average grain size for the entire core (fig. 6) are compared to those of the individual rock types it is clear that the energy systems from which the sediments were deposited were very effective in producing sediments of differing sorting values and average grain sizes.

The rock types have been placed in energy system categories in figure 7. The rock types are listed below in approximate order of decreasing energy intensity and increasing energy efficiency.

Conglomerate (type 07). Highest energy intensity, and lowest energy efficiency or shortest duration.

Pebbly brown sandstone (type 06). Moderately high energy of greater duration or efficiency than for the conglomerate, but shorter duration or efficiency than for the other rock types.

Massive brown sandstone (type 01). Medium energy intensity, and high efficiency or long duration.

Pebbly gray sandstone (type 06). This type, which by mineral composition, belongs with the brown sandstones, is almost identical to
<table>
<thead>
<tr>
<th>Relative Categories</th>
<th>Very High</th>
<th>High</th>
<th>Low</th>
<th>Very Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Bedded Brown Sandstone (02)</td>
<td>Massive Brown Sandstone (01)</td>
<td>Pebbly Gray Sandstone (06)</td>
<td>Massive Gray Sandstone (04)</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. Relationship of depositional environment to rock types.
massive brown sandstone in grain size and sorting, which indicates similar energy conditions at the site of deposition.

Bedded brown sandstone (type 02). Medium energy intensity, of very high efficiency or long duration.

Massive gray sandstone (type 04). Medium energy intensity but slightly less than for the massive brown sandstone. The duration or efficiency of the energy system is the same as that for the massive brown sandstone.

Bedded gray sandstone (type 05). Moderately low energy intensity, of medium duration or efficiency.

Disturbed structure shale (type 09). Very low energy intensity, of medium duration or efficiency.

Massive shale (type 08). Very low energy intensity, of good efficiency or long duration.

Graded bedding shale (type 10). Lowest energy intensity, of longest duration or highest efficiency.

Mixed disturbed structure and graded bedding shale (type 11). A mixture of the two named types; falls in an intermediate position between the two component types.

Thus far only the gross differences between rock types have been examined. These differences between rock types have made it possible to draw some conclusions as to relative differences in the amount of energy involved in the deposition of the different rock types. The next section is concerned with differences within the rock types. These internal differences make it possible to draw further conclusions concerning the type of energy system (waves, flowing water,
etc.) which may have been involved in the deposition of the rock types.

**Differences within rock types.**

Differences within a sedimentary unit will supply information which can be directly applied to an interpretation of its environment of deposition. Megascopic evidence of environmental vicissitudes can be seen in grain size, sorting, and structure. More subtle differences commonly are not seen at the macroscopic level but must be detected by microscopic study. The purpose of the following discussion is to mate and interpret both levels of information as much as is possible within each rock type.

Data from the Bartlett's test and the appendix are presented in figure 3 in such a manner that the average grain size, sorting, and illite content (differences between rock types) and the range of these variables (showing differences within rock types) may be directly compared for each of the sandstone rock types. The range is the difference between the maximum and minimum average by thin sections for the variable. For example the largest average grain size in any thin section of massive brown sandstone was 1.87 $\phi$ and the smallest average size was 2.74 $\phi$, therefore the range is 1.87 $\phi$ to 2.74 $\phi$.

A discussion of internal variables for the various rock types is presented below.

**Massive brown sandstone (01).** The range of $\phi$ is small and the range of $s^2$ is large. This phenomenon is a very distinctive feature of this rock type but the explanation is uncertain. Probably some type of structure is involved, perhaps on such a scale that it is not seen in the cores. The X-ray photographs mentioned earlier gave no hint of structure. Tests of association mentioned earlier failed to
**Figure 8.** A comparison of sandstone rock type variables.

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>( s^2 ) For Rock Type and Range of ( s^2 ) by Thin Section</th>
<th>( \bar{\sigma} ) For Rock Type and Range of ( \bar{\sigma} ) by Thin Section</th>
<th>% Illite for Rock Type and Range of % Illite by Thin Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Massive Brown Sandstone</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>02 Bedded Brown Sandstone</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>03 Pebbly Brown Sandstone</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>04 Massive Gray Sandstone</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>05 Bedded Gray Sandstone</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>06 Pebbly Gray Sandstone*</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
</tbody>
</table>

*Vertical marks show average value of rock type.

**Horizontal lines show range of values of rock type.

**Rock type 06 has been shown to belong with rock type 01 (See text).
show any association of grain size with sorting. The small range of average grain size indicates that the energy intensity must have remained at about the same level. The wide range of sorting values probably indicates that deposition was too rapid to allow equally efficient sorting at all times.

Bedded brown sandstone (02). The structure is suggestive of current bedding. The ranges of $\beta$ and $s^2$ are both small but cannot be considered to be especially meaningful, since only two thin sections were taken in this rock type.

Pebbly brown sandstone (03). The ranges of both $s^2$ and $\beta$ are relatively large. This probably reflects a time of somewhat more rapid deposition with less opportunity for reworking than for the massive brown sandstone.

Massive gray sandstone (04). The ranges of $\beta$ and $s^2$ are almost identical to those of the massive brown sandstone, but the average grain size is slightly smaller. The feature which most differentiates the two types is the much higher illite content of the massive gray sandstone. The conditions of deposition must have been quite similar for the two types. The total energy intensity may have been slightly less for the massive gray sandstone (as evidenced by its slightly smaller average grain size) and deposition may have been somewhat more rapid since the illite has not been removed by winnowing.

Bedded gray sandstone (05). This rock type is very distinctive. The range of $s^2$ is small while the range of $\beta$ is large. This distribution has led to an $s^2$ which is larger for the rock type as a whole than for any individual thin section. A large range for $\beta$ and a small range of $s^2$ is a condition produced by grading due to varying current
velocities (Pettijohn, 1957). In this type of grading an increase in grain size is dependent on increasing current velocity, which means that small grains may be carried away by the current, thereby increasing the average grain size but maintaining approximately the same variance. The thesis that these graded beds were deposited from flowing water is further supported by the presence of small scale cross-bedding, even though the occurrence of this cross-bedding is limited.

Pebbly gray sandstone (06). This rock type has been shown to belong with the brown sandstones on the basis of mineral composition. The exact placement in one of the three brown sandstone rock types cannot be made with great assurance since only two thin sections of the pebbly gray sandstone were made; however, it seems to resemble most closely the massive brown sandstone since both have almost the same variance and average grain size. This placement seems especially logical since the average grain size of the pebbly gray sandstone is actually outside the range of average grain size of both the bedded brown and pebbly brown sandstones.

Conglomerate (07). This rock type is not shown in a figure. From the data contained in the appendix it can be seen that the ranges of both $\bar{\sigma}$ and $s^2$ are much larger than those of any of the other rock types. This rock type represents the highest energy system of all the types and is the most rapidly deposited of all the types. Only two thin sections were taken and interpretation is limited.

The shale variables are presented in figure 9 in the same manner as for the sandstones in figure 8.

Massive shale (08). The ranges of $s^2$ and $\bar{\sigma}$ are both small. Energy
<table>
<thead>
<tr>
<th>Rock Type</th>
<th>$s^2$ For Rock Type and Range of $s^2$ by Thin Section</th>
<th>$\bar{\sigma}$ For Rock Type and Range of $\bar{\sigma}$ by Thin Section</th>
<th>% Quartz for Rock Type and Range of % Quartz by Thin Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 Massive Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09 Disturbed Structure Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Graded Bedding Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Mixed Disturbed Structure and Graded Bedding Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Vertical marks show average value of rock type.
** Horizontal lines show range of values of rock type.

Figure 9. A comparison of shale rock type variables.
intensity was low but sorting was good. Interpretation is difficult since only two thin sections were taken. This rock type is probably the same as the graded bedding shale except for a lesser amount of silt sized particles.

Graded bedding shale (10). The ranges of $\bar{\phi}$ and $\sigma^2$ are both small. This rock type represents the weakest energy system of all the types. Deposition may have been in relatively deep water, or in more shallow but very quiet water below wave base. The sediment may have come from periodic flooding or may have come from small scale turbidity flows. The close association with beds showing evidence of current or wave action and the fact that the shale units, in the field, grade laterally into sandstone tend to preclude the conclusion that the graded bedding shales could be the result of extensive or widespread turbidity flows.

Disturbed structure shale (C9). The ranges of $\bar{\phi}$ and $\sigma^2$ are both relatively large. Small scale cross-bedding is present in the silty layers but is limited in occurrence. The silt-poor layers are probably very closely related to the graded bedding shales but are distinguished from them largely by their association with the silty layers, penecontemporaneous deformation, and less obvious or absent grading of the beds. This rock type was deposited in a relatively low energy environment where the very quiet or still water was periodically interrupted by slowly moving currents or weak wave action. The thesis of periods of deposition from slowly moving currents is supported by the fact that the silty layers grade into the bedded gray sandstones which show evidence of current action.
Mixed disturbed structure and graded bedding shale (11). This is a mixture of the previous two rock types. The range of $s^2$ is very large and the range of $\bar{\phi}$ relatively large but not as large as that of the disturbed structure shale alone. The graded bedding shale seems to be the dominant member of this mixture. The intimate association of the two types in this mixture indicates that the differences in environment of deposition of the disturbed structure shale and the graded bedding shale must be very small.

The stratigraphic variations in energy systems are shown diagrammatically in figure 10. The diagram disregards the thickness of the units. It can be seen in this diagram that, from the bottom to the top of the section there has been a net change to increasing energy intensity and decreasing energy duration or efficiency indicating conditions of somewhat more rapid deposition.
This diagram does not show thicknesses of individual rock types. Each point represents one unit.

Figure 10. Stratigraphic variations in energy efficiency or duration and energy intensity as interpreted from sorting and average grain size of the rock types.
The source area of the Jackfork was probably composed of relatively fine grained sediments and metasediments. All the constituent particles of the formation are small and even the pebble sized rock fragments in the conglomerates are composed of small particles. Evidence favoring a sedimentary source includes a relatively simple quartz-clay mineral composition which would be unlikely with a petrographically complex parent rock. Rounded secondary overgrowth on some of the quartz grains indicates that these grains are at least second generation. The great thickness of the sedimentary series indicates rapid downwarping at the site of deposition and probably a rapidly rising source area. Thinning of the sediments toward the west and northwest indicates that the direction of the source was probably somewhere between east and south. These conclusions are in agreement with Bokman (1953) who suggested an upwarping to the south of part of the earlier filled geosyncline as a possible cause and source of the Jackfork sediments.

ENVIRONMENT OF DEPOSITION

Although overall deposition was rapid local processes were extremely effective in separating grain sizes into distinct well-sorted rock groups. The different rock types are themselves very well
sorted relative to the total sedimentary unit.

The conglomerates represent brief periods of intense current activity. The sandstones represent periods of relatively high energy but of variable intensity or character. The massive sandstones were rapidly deposited in an environment that was either basically inefficient in reworking, or which did not have sufficient time to rework the sediments. The pebbly sandstones are representative of somewhat more rapid deposition or less efficient reworking.

The bedded sandstones probably are the product of less intense but very efficient current activity. Bedded sandstone commonly is interbedded with shales and could be interpreted as the result of turbidity currents. These bedded sandstones, however, show no association of grain size and sorting, a property which is presumably typical of turbidite deposits (Pettijohn, 1957).

The shales represent the lowest energy depositional systems. The presence of some small scale cross-bedding in the disturbed structure shales indicates relatively weak current or wave action. Since graded bedding shales are closely associated with disturbed structure shale the graded bedding shales are probably also shallow water deposits but without disturbing agents. The close association of graded bedding and disturbed structure shales is emphasized by the mixed disturbed structure and graded bedding shale class which composes 13.2% of the section studied.

The depositional record seems to reflect periods of rapid and slow deposition, all in shallow water. Some episodes were relatively inefficient with respect to sorting whereas others produced extremely
well sorted sediments. From earliest to latest episodes there is a slight trend from lesser to greater intensity and from greater to lesser efficiency.
SELECTED REFERENCES


Branson, C. C., 1959, Regional relationships of Ouachita Mississippian and Pennsylvanian rocks, in The geology of the Ouachita Mountains, a symposium, Dallas Geol. Soc. and Ardmore Geol. Soc., pp. 118-121.


Cooper, C. L., 1945, Age relations of the Stanley and Jackfork formations of Oklahoma and Arkansas, Jour. Geology, v. 53, pp. 390-397.


Fenn, John C., 1957, Petrology of the Kittanning formation near Brookville, Pennsylvania, (Ph.D. dissertation), Dept. of Mineralogy, Penn. State Univ.


Goddard, E. N., et al., 1951, Rock-Color Chart, Geological Society of America, New York, N. Y.


Harlton, B. H., 1959, Age classification of the upper Pushmataha series in the Ouachita Mountains, in The geology of the Ouachita Mountains, a symposium, Dallas Geol. Soc. and Ardmore Geol. Soc., pp. 130-133.


Kremp, G. O. W., and Ames, H. T., 1959, Catalog of fossil spores and pollen, v. 5 and v. 6 (v. 5 - Carboniferous spores; v. 6 - Pennsylvanian spores), Pennsylvania State Univ., University Park, Pennsylvania.


Miser, H. D., 1921, Llanoria, the Paleozoic land area in Louisiana and eastern Texas, Am. Jour. Sci., 5th ser., v. 2, pp. 61-89.


Miser, H. D., 1943, Quartz veins in the Ouachita Mountains of Arkansas and Oklahoma (their relations to structure, metamorphism, and metalliferous deposits), Econ. Geol., v. 38, pp. 91-118.


Sellards, E. H., et al., 1932, Geology of Texas, Univ. of Texas Bull. 3232, v. 1, pp. 95, 131.


U. S. Army Engineer Waterways Experiment Station, 1961, Ouachita River and Tributaries, Arkansas and Louisiana, De Gray Reservoir, Caddo River, Arkansas, Design Memorandum No. 5-1, Vicksburg, Mississippi, 36 pp., 33 pl.


APPENDIX A

Mineral Composition and Grain Size Data of the Thin Sections
APPENDIX A

Explanation

The thin sections are listed by rock type. Their location is given in feet below the surface of the ground in the core from which they were taken. They were ground to a thickness of approximately 0.025 mm and mounted in caedax which has an index of refraction of approximately 1.55.

Both cores were vertical and both were taken on the west side of the river. Core G-8 is at 34° 12' 52-1/4" N and 93° 06' 41" W and ground level is at an elevation of 226.0 feet above mean sea level. Core G-9 is at 34° 12' 51-3/4" N and 93° 06' 43" W and ground level is at an elevation of 331.4 feet above mean sea level. The portion of core G-9 used in the study extended from a depth of 20.3 feet (elevation 311.1 feet) to 258.0 feet (elevation 73.4 feet), at which point the core was correlated with G-8. The correlation point in core G-8 was at a depth of 109.6 feet (elevation 116.3 feet). The portion of core G-8 used in the study extended from the correlation point with G-9 to a depth of 168.9 feet (elevation 57.0 feet). The total footage studied in core G-9 was 237.7 feet and in G-8 was 59.3 feet making a grand total of 297.0 feet.

The mineral composition of each thin section was calculated by determining the mineral encountered at 100 separate points in each thin section.

The average grain size was determined by measuring the apparent
long axes of 20 randomly selected quartz grains. The data are numbered from one to 20 in the order in which the grains were measured.

The color of the rock chips was determined by comparing them with the G.S.A. Rock-Color Chart (Goddard, et al., 1951).
APPENDIX A

Rock Type 01 Massive Brown Sandstone

Thin Section Number 01/01

Depth Below Surface (in feet) 25.9

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>61</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td>1. 0.1544</td>
</tr>
<tr>
<td>Siderite</td>
<td>19</td>
<td>2. 0.1670</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>3. 0.0874</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>4. 0.4198</td>
</tr>
<tr>
<td>Silica cement</td>
<td>5</td>
<td>5. 0.2858</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
<td>6. 0.2244</td>
</tr>
<tr>
<td>Chert</td>
<td>7</td>
<td>7. 0.1010</td>
</tr>
<tr>
<td>Sericite</td>
<td>8</td>
<td>8. 0.0798</td>
</tr>
<tr>
<td>Pyrite</td>
<td>9</td>
<td>9. 0.1916</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>10</td>
<td>10. 0.0914</td>
</tr>
<tr>
<td>Kaolin</td>
<td>11</td>
<td>11. 0.4318</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>12</td>
<td>12. 0.0868</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>13</td>
<td>13. 0.1194</td>
</tr>
<tr>
<td>Chlorite</td>
<td>14</td>
<td>14. 0.4340</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>15</td>
<td>15. 0.1494</td>
</tr>
<tr>
<td>Zircon</td>
<td>16</td>
<td>16. 0.0776</td>
</tr>
<tr>
<td>Microcline</td>
<td>17</td>
<td>17. 0.3250</td>
</tr>
<tr>
<td>Limonite</td>
<td>18</td>
<td>18. 0.0466</td>
</tr>
<tr>
<td>Magnetite</td>
<td>19</td>
<td>19. 0.2434</td>
</tr>
<tr>
<td>Biotite</td>
<td>20</td>
<td>20. 0.1426</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.1930
Average grain size in Ø 2.6566
Variance (s²) calculated in Ø 0.8734
Color of rock chip 4 YR 5/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number 01/02

Depth Below Surface (in feet) 31.0

Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>72</td>
<td>0.1592</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>6</td>
<td>0.1122</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>8</td>
<td>0.1124</td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td>0.1188</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>0.1986</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>0.0992</td>
</tr>
<tr>
<td>Muscovite</td>
<td>6</td>
<td>0.6670</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>0.2562</td>
</tr>
<tr>
<td>Calcite</td>
<td>4</td>
<td>0.1008</td>
</tr>
<tr>
<td>Chert</td>
<td>5</td>
<td>0.2568</td>
</tr>
<tr>
<td>Sericite</td>
<td>6</td>
<td>0.5842</td>
</tr>
<tr>
<td>Pyrite</td>
<td>7</td>
<td>0.0806</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>8</td>
<td>0.0342</td>
</tr>
<tr>
<td>Kaolin</td>
<td>9</td>
<td>0.1318</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>10</td>
<td>0.1668</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>11</td>
<td>0.1130</td>
</tr>
<tr>
<td>Chlorite</td>
<td>12</td>
<td>0.1722</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>13</td>
<td>0.1250</td>
</tr>
<tr>
<td>Zircon</td>
<td>14</td>
<td>0.3648</td>
</tr>
<tr>
<td>Microcline</td>
<td>15</td>
<td>0.4258</td>
</tr>
<tr>
<td>Limonite</td>
<td>16</td>
<td>0.1888</td>
</tr>
<tr>
<td>Magnetite</td>
<td>17</td>
<td>2.7276</td>
</tr>
<tr>
<td>Biotite</td>
<td>18</td>
<td>0.9253</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in \( \text{mm} \) 0.1888

Average grain size in \( \varnothing \) 2.7276

Variance \( (s^2) \) calculated in \( \varnothing \) 0.9253

Color in rock chip 4 YR 5/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number  01/03

Depth Below Surface (in feet)  32.7

Core Number  G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>1.0906</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>0.0906</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.0906</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Chlortite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Microcline</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Rutile</td>
<td>1</td>
<td>0.0906</td>
</tr>
<tr>
<td>Garnet</td>
<td>1</td>
<td>0.0906</td>
</tr>
</tbody>
</table>

Total  100

Average grain size in mm  0.3298
Average grain size in Ø  2.1516
Variance (s^2) calculated in Ø  1.8515
Color in rock chip  4 YR 5/1
## APPENDIX A

**Rock Type 01**  
**Massive Brown Sandstone**

**Thin Section Number** 01/04  
**Depth Below Surface (in feet)** 34.6  
**Core Number** G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
<th>mm</th>
<th>(\phi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dusty quartz</td>
<td>76</td>
<td></td>
<td>1</td>
<td>0.1536</td>
</tr>
<tr>
<td></td>
<td>Clear quartz</td>
<td>5</td>
<td></td>
<td>2</td>
<td>0.0430</td>
</tr>
<tr>
<td></td>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
<td>3</td>
<td>0.0824</td>
</tr>
<tr>
<td></td>
<td>Illite</td>
<td>4</td>
<td></td>
<td>4</td>
<td>0.1630</td>
</tr>
<tr>
<td></td>
<td>Siderite</td>
<td>5</td>
<td></td>
<td>5</td>
<td>0.2004</td>
</tr>
<tr>
<td></td>
<td>Carbonaceous matter</td>
<td>-</td>
<td></td>
<td>6</td>
<td>0.8312</td>
</tr>
<tr>
<td></td>
<td>Muscovite</td>
<td>2</td>
<td></td>
<td>7</td>
<td>0.2106</td>
</tr>
<tr>
<td></td>
<td>Silica cement</td>
<td>4</td>
<td></td>
<td>8</td>
<td>0.1896</td>
</tr>
<tr>
<td></td>
<td>Calcite</td>
<td>-</td>
<td></td>
<td>9</td>
<td>0.2648</td>
</tr>
<tr>
<td></td>
<td>Chert</td>
<td>-</td>
<td></td>
<td>10</td>
<td>0.2552</td>
</tr>
<tr>
<td></td>
<td>Sericite</td>
<td>1</td>
<td></td>
<td>11</td>
<td>0.5432</td>
</tr>
<tr>
<td></td>
<td>Pyrite</td>
<td>-</td>
<td></td>
<td>12</td>
<td>0.2168</td>
</tr>
<tr>
<td></td>
<td>Plagioclase</td>
<td>-</td>
<td></td>
<td>13</td>
<td>0.2656</td>
</tr>
<tr>
<td></td>
<td>Kaolin</td>
<td>1</td>
<td></td>
<td>14</td>
<td>0.1430</td>
</tr>
<tr>
<td></td>
<td>Leucoxene</td>
<td>1</td>
<td></td>
<td>15</td>
<td>0.0944</td>
</tr>
<tr>
<td></td>
<td>Orthoclase</td>
<td>-</td>
<td></td>
<td>16</td>
<td>0.1686</td>
</tr>
<tr>
<td></td>
<td>Chlorite</td>
<td>-</td>
<td></td>
<td>17</td>
<td>0.2744</td>
</tr>
<tr>
<td></td>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
<td>18</td>
<td>0.2248</td>
</tr>
<tr>
<td></td>
<td>Zircon</td>
<td>-</td>
<td></td>
<td>19</td>
<td>0.2424</td>
</tr>
<tr>
<td></td>
<td>Microcline</td>
<td>-</td>
<td></td>
<td>20</td>
<td>0.3576</td>
</tr>
<tr>
<td></td>
<td>Limonite</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magnetite</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biotite</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rutile</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Garnet</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|               | Total            | 100   |           |    |         |         |

- Average grain size in \(\text{mm}\): \(2.4623\)
- Average grain size in \(\phi\): \(2.2953\)
- Variance \((s^2)\) calculated in \(\phi\): \(0.8441\)
- Color in rock chip: 4 YR 5/1
APPENDIX A

Rock Type 01 Massive Brown Sandstone

Thin Section Number 01/05

Depth Below Surface (in feet) 39.4

Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>1.0.2792</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.0.0722</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3.0.0942</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4.0.1602</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.0.1484</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>6.0.2624</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>7.0.6312</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0.1630</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9.0.1104</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0.2104</td>
</tr>
<tr>
<td>Leucozene</td>
<td>-</td>
<td>11.0.0974</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0.1224</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0.1544</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0.3744</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0.0562</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0.1314</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0.1438</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td>18.0.2104</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.0.1402</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0.4008</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.1982
Average grain size in Ø 2.5929
Variance (s²) calculated in Ø 0.7305
Color in rock chip 4 YR 5/1
# APPENDIX A

**Rock Type 01**  
Massive Brown Sandstone

**Thin Section Number**  
01/06

**Depth Below Surface (in feet)**  
41.6

**Core Number**  
G-9

## Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>29</td>
<td>1. 0.2072</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.3752</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.1168</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.1224</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.1824</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1032</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.3776</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.3104</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.2056</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.2808</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.3488</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.2032</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1752</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.1384</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.2728</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.2872</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.3904</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1928</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.1752</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.2248</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

| Total                   | 100|            |

**Average grain size in mm**  
0.2345

**Average grain size in φ**  
2.2004

**Variance (s²) calculated in φ**  
0.3412

**Color in rock chip**  
5 YR 5 1/2
### APPENDIX A

**Rock Type 01**  
**Massive Brown Sandstone**

**Thin Section Number**  
01/07

**Depth Below Surface (in feet)**  
43.3

**Core Number**  
G-9

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>68</td>
<td>0.2416 2.0493</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td>0.0736 3.7642</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td>0.1544 2.6953</td>
</tr>
<tr>
<td>Illite</td>
<td>5</td>
<td>0.0896 3.4804</td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>0.3032 1.7217</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>0.1456 2.7799</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>0.0156 3.2324</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.0832 3.5873</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>0.1064 3.9012</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>0.0031 4.6128</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>0.0832 3.5873</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.1648 2.6012</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>0.0992 3.3335</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.1168 3.0979</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>0.1800 2.4739</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>0.2656 1.9127</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.1208 3.0493</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>2</td>
<td>0.2072 2.2709</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.1608 2.6367</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.2568 1.9613</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>0.1496 2.7408</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td>0.2504 1.9977</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.0928 3.4297</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>4 IR 5/1</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Total**  
100

**Average grain size in mm**  
0.1631

**Average grain size in Ø**  
2.7408

**Variance (s²) calculated in Ø**  
0.3837
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number 01/08
Depth Below Surface (in feet) 44.5
Core Number G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>15</td>
<td>1.0.3496</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>2.0.1192</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3.0.4240</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4.0.9576</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.0.0464</td>
</tr>
<tr>
<td>Chert</td>
<td>3</td>
<td>6.0.4376</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.0.0464</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0.1744</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9.0.1296</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>10.0.5192</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.0.0864</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0.2096</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0.1896</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0.1864</td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td>15.0.2104</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0.5376</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0.4944</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0.1248</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.0.2216</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0.1368</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in \( \text{mm} \) 0.2801
Average grain size in \( \phi \) 2.2583
Variance \( (s^2) \) calculated in \( \phi \) 1.3637
Color of rock chip 4 TR 5/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number 01/09

Depth Below Surface (in feet) 46.2

Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>77</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>11</td>
<td>1. 0.3368</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>2. 0.5728</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.1144</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4. 0.3840</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.3696</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>6. 0.2184</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0872</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8. 0.1024</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0808</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>10. 0.2136</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>11. 0.4888</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.4184</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.5536</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>2</td>
<td>14. 0.3664</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0552</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>16. 0.1384</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.2216</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.2176</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>19. 0.2944</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>20. 0.2424</td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.2738

Average grain size in ø 2.1492

Variance (σ^2) calculated in ø 0.9772

Color of rock chip 4 YR 5/1
### APPENDIX A

**Rock Type 01**  
Massive Brown Sandstone

**Thin Section Number**  
01/10

**Depth Below Surface (in feet)**  
47.0

**Core Number**  
5-9

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1.0.2176</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>2.0.1248</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>3.0.2168</td>
</tr>
<tr>
<td>Silica cement</td>
<td>8</td>
<td>4.0.1400</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5.0.1616</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6.0.1624</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7.0.4728</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8.0.2832</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9.0.1784</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10.0.1576</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11.0.2632</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12.0.1376</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13.0.3928</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14.0.2184</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15.0.4176</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16.0.2984</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17.0.1144</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18.0.1232</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19.0.1292</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20.0.2856</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  
0.2248

Average grain size in Ø  
2.2897

Variance ($s^2$) calculated in Ø  
0.3964

Color of rock chip  
4 YR 5/1
## APPENDIX A

**Rock Type 01**  Massive Brown Sandstone

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>01/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>54.9</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>4</td>
<td>0.4648, 1.1053</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>0.1192, 3.0685</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>0.1776, 2.4933</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>0.3184, 1.6511</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>0.2144, 2.2216</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>0.2736, 1.8699</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>0.1832, 2.4485</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>0.4376, 1.1923</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>0.4648, 1.1053</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>0.2472, 2.0162</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>0.2512, 1.9931</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>0.2744, 1.8656</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.2312, 2.1128</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.2736, 1.8699</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.3128, 1.6767</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.2256, 2.1482</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>0.1816, 2.4612</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.4408, 1.1818</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>0.3136, 1.6730</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.3936, 1.3452</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Total 100

- Average grain size in mm 0.2900
- Average grain size in Ø 1.8750
- Variance (s²) calculated in Ø 0.2793
- Color of rock chip 4 TR 5/1
### APPENDIX A

**Rock Type 01**

**Massive Brown Sandstone**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>01/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>56.3</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>71</td>
<td>0.2328</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>15</td>
<td>0.3000</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td>0.2072</td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td>0.2848</td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>0.5296</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>0.2616</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>0.5368</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.1672</td>
</tr>
<tr>
<td>Calcite</td>
<td>7</td>
<td>0.2416</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>0.0936</td>
</tr>
<tr>
<td>Sericite</td>
<td>11</td>
<td>0.4416</td>
</tr>
<tr>
<td>Pyrite</td>
<td>10</td>
<td>0.2424</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>15</td>
<td>0.1832</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>0.3632</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>12</td>
<td>0.1616</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>13</td>
<td>0.1688</td>
</tr>
<tr>
<td>Chlorite</td>
<td>14</td>
<td>0.1584</td>
</tr>
<tr>
<td>Micasaceous rock frag.</td>
<td>15</td>
<td>0.5256</td>
</tr>
<tr>
<td>Zircon</td>
<td>16</td>
<td>0.1184</td>
</tr>
<tr>
<td>Microcline</td>
<td>17</td>
<td>0.2664</td>
</tr>
<tr>
<td>Limonite</td>
<td>18</td>
<td>2.0957</td>
</tr>
<tr>
<td>Magnetite</td>
<td>19</td>
<td>0.5693</td>
</tr>
<tr>
<td>Biotite</td>
<td>20</td>
<td>3.0783</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.2664</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>2.0957</td>
</tr>
</tbody>
</table>

**Total** 100

#### Average grain size in mm

<table>
<thead>
<tr>
<th>Average grain size in mm</th>
<th>0.2664</th>
</tr>
</thead>
</table>

#### Average grain size in \( \phi \)

<table>
<thead>
<tr>
<th>Average grain size in ( \phi )</th>
<th>2.0957</th>
</tr>
</thead>
</table>

#### Variance \( (s^2) \) calculated in \( \phi \)

<table>
<thead>
<tr>
<th>Variance ( (s^2) ) calculated in ( \phi )</th>
<th>0.5693</th>
</tr>
</thead>
</table>

#### Color of rock chip

<table>
<thead>
<tr>
<th>Color of rock chip</th>
<th>4 YR 5/1</th>
</tr>
</thead>
</table>

### APPENDIX A

**Rock Type 01**  
**Massive Brown Sandstone**  

**Thin Section Number**  
01/13

**Depth Below Surface (in feet)**  
57.0

**Core Number**  
G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.1945

**Average grain size in Ø**  
2.4942

**Variance (σ²) calculated in Ø**  
0.4451

**Color of rock chip**  
4 YR 5/1
### APPENDIX A

**Rock Type 01**

**Massive Brown Sandstone**

**Thin Section Number** 01/14

**Depth Below Surface (in feet)** 70.6

**Core Number** G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>1.0744</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.01376</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.02984</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4.01792</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.01816</td>
</tr>
<tr>
<td>Chert</td>
<td>3</td>
<td>6.01944</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.04728</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.02856</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9.01992</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.01472</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.02448</td>
</tr>
<tr>
<td>Orthoelase</td>
<td>-</td>
<td>12.02568</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.05360</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td>14.01048</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.01664</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.02744</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.02616</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.00832</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.01360</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.00952</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

| Total                     | 100   |

**Average grain size in mm** 0.2165

**Average grain size in ø** 2.4016

**Variance (s²) calculated in ø** 0.5880

**Color of rock chip** 4 IR 5/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number  01/15

Depth Below Surface (in feet)  72.6

Core Number  G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>10</td>
<td>1. 0.0856</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td>2. 0.0872</td>
</tr>
<tr>
<td>Silica cement</td>
<td>5</td>
<td>3. 0.2448</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>4. 0.2883</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>5. 0.2256</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>6. 0.0712</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>7. 0.1776</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>8. 0.0904</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>9. 0.3528</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>10. 0.0944</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>11. 0.2096</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>12. 0.1704</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td>13. 0.2808</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>14. 0.2752</td>
</tr>
<tr>
<td>Micacline</td>
<td>1</td>
<td>15. 0.2872</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>16. 0.0496</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>17. 0.2376</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>18. 0.2576</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>19. 0.1616</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td>20. 0.2552</td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm  0.1952
Average grain size in Ø  2.5491
Variance (s²) calculated in Ø  0.6813
Color of rock chip  4 YR 5/1
**APPENDIX A**

Rock Type 01  
Massive Brown Sandstone

**Thin Section Number**  
01/16

**Depth Below Surface (in feet)**  
77.7

**Core Number**  
G-9

---

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>10</td>
<td>1. 0.4536</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.2712</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3. 0.1528</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.2392</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.4496</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6. 0.2472</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.2064</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.3016</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>9. 0.3792</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.3238</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.3944</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>12. 0.1912</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.3344</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.1432</td>
</tr>
<tr>
<td>Zircon</td>
<td>2</td>
<td>15. 0.0440</td>
</tr>
<tr>
<td>Microcline</td>
<td>1</td>
<td>16. 0.1840</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.2096</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.2232</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.1920</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1912</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm  
0.2520

Average grain size in $\phi$  
2.1361

Variance ($s^2$) calculated in $\phi$  
0.5472

Color of rock chip  
4 YR 5/1
APPENDIX A

Rock Type 01 Massive Brown Sandstone

Thin Section Number 01/17

Depth Below Surface (in feet) 102.0

Core Number G-9

Composion

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>1.0.2792</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>0.3464</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>0.3768</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>0.2016</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>0.1904</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>0.6816</td>
</tr>
<tr>
<td>Sericite</td>
<td>8</td>
<td>0.1744</td>
</tr>
<tr>
<td>Pyrite</td>
<td>9</td>
<td>0.0584</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>10</td>
<td>0.0200</td>
</tr>
<tr>
<td>Kaolin</td>
<td>11</td>
<td>0.3784</td>
</tr>
<tr>
<td>Leucocene</td>
<td>12</td>
<td>0.1184</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>13</td>
<td>0.4392</td>
</tr>
<tr>
<td>Chlorite</td>
<td>14</td>
<td>0.2544</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>15</td>
<td>0.1928</td>
</tr>
<tr>
<td>Zircon</td>
<td>16</td>
<td>0.2424</td>
</tr>
<tr>
<td>Microcline</td>
<td>17</td>
<td>0.1216</td>
</tr>
<tr>
<td>Limonite</td>
<td>18</td>
<td>0.3432</td>
</tr>
<tr>
<td>Magnetite</td>
<td>19</td>
<td>0.1528</td>
</tr>
<tr>
<td>Biotite</td>
<td>20</td>
<td>0.2040</td>
</tr>
<tr>
<td>Rutile</td>
<td>21</td>
<td>0.2934</td>
</tr>
<tr>
<td>Garnet</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.2677

Average grain size in \( \phi \) 2.0945

Variance \( (s^2) \) calculated in \( \phi \) 0.6330

Color of rock chip 4 YR 5/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number  01/18

Depth Below Surface (in feet)  47.9

Core Number  G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>82</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>1. 0.1736</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>2. 0.3504</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.1424</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4. 0.1256</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>5. 0.2208</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>6. 0.1704</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>7. 0.2288</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8. 0.2656</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>9. 0.2392</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>10. 0.2064</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>11. 0.2160</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>12. 0.1792</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>13. 0.1824</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>14. 0.2784</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>15. 0.1944</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>16. 0.1992</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>17. 0.3448</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>18. 0.2632</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td>19. 0.4752</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td>20. 0.2224</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: 100

Average grain size in mm  0.2329
Average grain size in ø  2.1728
Variance (s²) calculated in ø  0.2028
Color of rock chip  4 YR 6/1
APPENDIX A

Rock Type 01 H asair* Brown Sandstone

Thin Section Number 01/19
Depth Below Surface (in feet) 48.4
Core Number G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>80</td>
<td>0.3240</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>0.5896</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>0.1192</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>0.0840</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>1.6936</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>0.1688</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>0.2824</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>0.2224</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.2120</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>0.1440</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.1448</td>
</tr>
<tr>
<td>Leucochrome</td>
<td>11</td>
<td>0.2536</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.6232</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.3456</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>0.1648</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>0.3312</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>0.0672</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>0.1408</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>0.2944</td>
</tr>
<tr>
<td>Rutile</td>
<td>19</td>
<td>0.3592</td>
</tr>
<tr>
<td>Garnet</td>
<td>20</td>
<td>0.2384</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total 100</td>
</tr>
</tbody>
</table>

Average grain size in mm 0.3240
Average grain size in φ 2.0724
Variance (σ²) calculated in φ 1.1288
Color of rock chip 4 IR 6/1
# APPENDIX A

## Rock Type 01

**Massive Brown Sandstone**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>01/20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>50.9</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

## Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>75</td>
<td>1. 0.0624</td>
<td>4.0023</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td>2. 0.1312</td>
<td>2.9302</td>
</tr>
<tr>
<td>Illite-Illite-Siderite</td>
<td>-</td>
<td>3. 0.1928</td>
<td>2.3748</td>
</tr>
<tr>
<td>Illite</td>
<td>5</td>
<td>4. 0.1064</td>
<td>3.2324</td>
</tr>
<tr>
<td>Siderite</td>
<td>4</td>
<td>5. 0.2536</td>
<td>1.9794</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>6. 0.1760</td>
<td>2.5064</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>7. 0.2712</td>
<td>1.8826</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>8. 0.1464</td>
<td>2.7720</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>9. 0.4024</td>
<td>1.3133</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>10. 0.4408</td>
<td>1.1818</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>11. 0.1920</td>
<td>2.3808</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td>12. 0.1632</td>
<td>2.6153</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>13. 0.1192</td>
<td>3.0685</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>14. 0.2872</td>
<td>1.7999</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>15. 0.2168</td>
<td>2.2056</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>16. 0.1424</td>
<td>2.8120</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>17. 0.3848</td>
<td>1.3778</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>18. 0.1056</td>
<td>3.2433</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>19. 0.1664</td>
<td>2.5873</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>20. 0.5464</td>
<td>0.8720</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total 100

- **Average grain size in mm**: 0.2254
- **Average grain size in µ**: 2.3569
- **Variance (s²) calculated in µ**: 0.6290
- **Color of rock chip**: 3 YR 6/1
## APPENDIX A

**Rock Type 01** Massive Brown Sandstone

**Thin Section Number** 01/21

**Depth Below Surface (in feet)** 51.2

**Core Number** G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>82</td>
<td>1.8406</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
<td>1.6475</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td>2.6295</td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td>0.7622</td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>1.7255</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>0.7939</td>
</tr>
<tr>
<td>Mica</td>
<td></td>
<td>1.8656</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>1.2681</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>2.0398</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>2.1533</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>1.7642</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>2.7799</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>2.1950</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>2.2002</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>3.4548</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>1.3335</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>1.9302</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>1.7447</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>1.8448</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>2.7255</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td>2.7255</td>
</tr>
</tbody>
</table>

**Total** 100

**Average grain size in mm** 0.2870

**Average grain size in Ø** 1.9349

**Variance (σ²) calculated in Ø** 0.4224

**Color of rock chip** 2 YR 6/1
APPENDIX A

Rock Type 01 Massive Brown Sandstone

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>01/22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>64.3</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>81</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
</tr>
<tr>
<td>Flagiolase</td>
<td>3</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
</tbody>
</table>

| Total                  | 100 |

<table>
<thead>
<tr>
<th>Grain Size</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Size</td>
<td></td>
</tr>
<tr>
<td>mm</td>
<td>0.1512</td>
</tr>
<tr>
<td>mm</td>
<td>0.1424</td>
</tr>
<tr>
<td>mm</td>
<td>0.2048</td>
</tr>
<tr>
<td>mm</td>
<td>0.2616</td>
</tr>
<tr>
<td>mm</td>
<td>0.1712</td>
</tr>
<tr>
<td>mm</td>
<td>0.2168</td>
</tr>
<tr>
<td>mm</td>
<td>0.2216</td>
</tr>
<tr>
<td>mm</td>
<td>0.2792</td>
</tr>
<tr>
<td>mm</td>
<td>0.2256</td>
</tr>
<tr>
<td>mm</td>
<td>0.4968</td>
</tr>
<tr>
<td>mm</td>
<td>0.2552</td>
</tr>
<tr>
<td>mm</td>
<td>0.2256</td>
</tr>
<tr>
<td>mm</td>
<td>0.3704</td>
</tr>
<tr>
<td>mm</td>
<td>0.5824</td>
</tr>
<tr>
<td>mm</td>
<td>0.1608</td>
</tr>
<tr>
<td>mm</td>
<td>0.2080</td>
</tr>
<tr>
<td>mm</td>
<td>0.2808</td>
</tr>
<tr>
<td>mm</td>
<td>0.3040</td>
</tr>
<tr>
<td>mm</td>
<td>0.1376</td>
</tr>
<tr>
<td>mm</td>
<td>0.3352</td>
</tr>
</tbody>
</table>

Average grain size in mm 0.2616
Average grain size in Ø 2.0453
Variance (s^2) calculated in Ø 0.3142
Color of rock chip 5 YR 6/1
APPENDIX A

Rock Type 01  Massive Brown Sandstone

Thin Section Number  01/23

Depth Below Surface (in feet)  98.1

Core Number  G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>4</td>
<td>1.03576</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.04064</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.02200</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4.02584</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.01904</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>6.01664</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.01432</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.00912</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9.02344</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.04416</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.03584</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>12.02712</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>13.00584</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.06912</td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td>15.07096</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.03768</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.03224</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.04240</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.01392</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.07744</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.3318
Average grain size in Ø   1.8706
Variance (s²) calculated in Ø  0.9446
Color of rock chip        5 YR 6/1
APPENDIX A

Rock Type 01  
Massive Brown Sandstone

Thin Section Number  
01/24

Depth Below Surface (in feet)  
98.3

Core Number  
G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>83</td>
<td>0.4568</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>1</td>
<td>0.0648</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td>0.3632</td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td>0.1944</td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>0.2600</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>0.2648</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>0.1504</td>
</tr>
<tr>
<td>Silica cement</td>
<td>6</td>
<td>0.3568</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>0.1446</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>0.1912</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>0.2680</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>0.2632</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>0.2544</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.2664</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>0.2632</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.2544</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.2912</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.2064</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.1880</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.1592</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>0.2296</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.0644</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.0644</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.0644</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>0.0644</td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.2349
Average grain size in ø 2.2363
Variance (s^2) calculated in ø 0.5241
Color of rock chip 5 YR 6/1
### APPENDIX A

**Rock Type 02**  
Bedded Brown Sandstone

**Thin Section Number**  
02/01

**Depth Below Surface (in feet)**  
60.0

**Core Number**  
G-9

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.1954

**Average grain size in Ø**  
2.5207

**Variance (s^2) calculated in Ø**  
0.5004

**Color of rock chip**  
4 YR 5/1
APPENDIX A

Rock Type 02  Bedded Brown Sandstone

Thin Section Number  02/02

Depth Below Surface (in feet)  60.1

Core Number  G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>0.0904</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.2792</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
<td>0.2184</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>0.0864</td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
<td>0.2152</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.1120</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>0.2680</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>0.2184</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>0.2800</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>0.2672</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.3048</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.2328</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.1344</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.1344</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>0.3784</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.1824</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.2568</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.1960</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.2106
Average grain size in Ø  2.3504
Variance (s²) calculated in Ø  0.3426
Color of rock chip  5 YR 5/1
APPENDIX A

Rock Type 03  Pebble Brown Sandstone

Thin Section Number  03/01

Depth Below Surface (in feet)  58.1

Core Number  G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>9</td>
<td>1. 0.5136</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1672</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>3. 0.1032</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.1672</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.3848</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6. 0.2552</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.1624</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.1792</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0936</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.2416</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.3152</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0864</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1912</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.2376</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.1864</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.2112</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.1504</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.2416</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.2344</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 2.9251</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.3524
Average grain size in Ø  2.1484
Variance (s²) calculated in Ø  1.1555
Color of rock chip  4 YR 4/1
<table>
<thead>
<tr>
<th>Zircon</th>
<th>1.263</th>
<th>1.302</th>
<th>1.355</th>
<th>1.358</th>
<th>1.458</th>
<th>1.609</th>
<th>1.772</th>
<th>1.922</th>
<th>1.935</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscovite</td>
<td>1.624</td>
<td>1.628</td>
<td>1.635</td>
<td>1.638</td>
<td>1.646</td>
<td>1.650</td>
<td>1.652</td>
<td>1.655</td>
<td>1.658</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1.838</td>
<td>1.840</td>
<td>1.843</td>
<td>1.846</td>
<td>1.850</td>
<td>1.855</td>
<td>1.858</td>
<td>1.864</td>
<td>1.867</td>
</tr>
<tr>
<td>Hornblende</td>
<td>1.929</td>
<td>1.932</td>
<td>1.935</td>
<td>1.938</td>
<td>1.940</td>
<td>1.944</td>
<td>1.945</td>
<td>1.948</td>
<td>1.950</td>
</tr>
<tr>
<td>Pyrophyllite</td>
<td>2.019</td>
<td>2.022</td>
<td>2.025</td>
<td>2.028</td>
<td>2.030</td>
<td>2.034</td>
<td>2.035</td>
<td>2.037</td>
<td>2.038</td>
</tr>
<tr>
<td>Sillimanite</td>
<td>2.099</td>
<td>2.101</td>
<td>2.103</td>
<td>2.105</td>
<td>2.107</td>
<td>2.110</td>
<td>2.112</td>
<td>2.114</td>
<td>2.115</td>
</tr>
<tr>
<td>Muscovite + Chlorite</td>
<td>1.624</td>
<td>1.628</td>
<td>1.635</td>
<td>1.638</td>
<td>1.646</td>
<td>1.650</td>
<td>1.652</td>
<td>1.655</td>
<td>1.658</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Staurolite</td>
<td>2.189</td>
<td>2.192</td>
<td>2.194</td>
<td>2.197</td>
<td>2.199</td>
<td>2.203</td>
<td>2.205</td>
<td>2.207</td>
<td>2.209</td>
</tr>
<tr>
<td>Actinolite</td>
<td>1.838</td>
<td>1.840</td>
<td>1.843</td>
<td>1.846</td>
<td>1.850</td>
<td>1.855</td>
<td>1.858</td>
<td>1.864</td>
<td>1.867</td>
</tr>
<tr>
<td>Fe-Ti-Scottite</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Rock Type**

- **Origin:** Fe-Ti-Scottite
- **Mineralogy:**
  - Muscovite
  - Chlorite
  - Hornblende
  - Pyrophyllite
  - Sillimanite
  - Muscovite + Chlorite
  - Carbonaceous matter
  - Staurolite
  - Actinolite
  - Fe-Ti-Scottite

**Properties**

- **Color:** Brown
- **Texture:** Sandstone
- **Rock Type:** 03
- **Section Number:** 03/02
- **Depth Below Surface (in feet):** 63.4
- **Core Number:** 0-9

**Composition**

- **Grain Size:**
  - 100 µm
  - 100 µm
  - 100 µm
  - 100 µm

**Appendix A**

- **Table:**
  - 106
**APPENDIX A**

**Rock Type 03**  
Pebbly Brown Sandstone

**Thin Section Number**  
03/03

**Depth Below Surface (in feet)**  
90.3

**Core Number**  
G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>1</td>
<td>mm</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1.0.3720</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.0.2672</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.0.6384</td>
</tr>
<tr>
<td>Silica cement</td>
<td>5</td>
<td>4.0.1936</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.1.4392</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6.0.3296</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.0.3032</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0.4584</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9.0.5288</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0.2016</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.0.3312</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0.3600</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0.3992</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0.6504</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0.2632</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0.4416</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0.0856</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0.4384</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.1.2944</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0.2840</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.4640

**Average grain size in Ø**  
1.3899

**Variance (s^2) calculated in Ø**  
0.8258

**Color of rock chip**  
5 TR 8/1
APPENDIX A

Rock Type 03  Pebble Brown Sandstone

Thin Section Number  03/04

Depth Below Surface (in feet)  91.0

Core Number  G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>0.4376</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>0.8804</td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td>1.3899</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.2368</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>2.0783</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>0.3080</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>1.6900</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td>0.4944</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>1.0162</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.5242

Average grain size in Ø  1.2345

Variance (s²) calculated in Ø  0.8263

Color of rock chip  5 YR 8/1
APPENDIX A

Rock Type Q4   Massive Gray Sandstone

Thin Section Number     04/01
Depth Below Surface (in feet)     163.9
Core Number     G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>0.1592</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>0.1544</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>0.1296</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>0.1232</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>0.2616</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>0.1624</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>0.0648</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.2664</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>0.3368</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.1768</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>0.2352</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.1136</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.2160</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>0.1720</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>0.2664</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>0.1592</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>0.1672</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>0.1720</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td>0.2568</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td>0.3048</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm          0.1949
Average grain size in Ø            2.4565
Variance (s^2) calculated in Ø      0.3206
Color of rock chip                   N5
APPENDIX A

Rock Type 04 Massive Gray Sandstone

Thin Section Number 04/02

Depth Below Surface (in feet) 169.6

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>79</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.1992</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.3216</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3. 0.5288</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.2328</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.1752</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1704</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.3768</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.1752</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.2968</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.4744</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>11. 0.1432</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>12. 0.1912</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1184</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.5056</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.1832</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.1288</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.1536</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1344</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.2432</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1736</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.2463
Average grain size in Ø 2.1812
Variance (\(s^2\)) calculated in Ø 0.4495
Color of rock chip N 6
APPENDIX A

Rock Type Q4  
Massive Gray Sandstone

Thin Section Number  
Q4/03

Depth Below Surface (in feet)  
170.5

Core Number  
G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dusty quartz</td>
<td>68</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Clear quartz</td>
<td>11</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Illite-Siderite</td>
<td>-</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Illite</td>
<td>3</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>Siderite</td>
<td>1</td>
<td>mm 2.1028</td>
</tr>
<tr>
<td></td>
<td>Carbonaceous matter</td>
<td>4</td>
<td>mm 3.0116</td>
</tr>
<tr>
<td></td>
<td>Muscovite</td>
<td>1</td>
<td>mm 3.0116</td>
</tr>
<tr>
<td></td>
<td>Silica cement</td>
<td>2</td>
<td>mm 3.1688</td>
</tr>
<tr>
<td></td>
<td>Calcite</td>
<td>6</td>
<td>mm 3.1078</td>
</tr>
<tr>
<td></td>
<td>Chert</td>
<td>7</td>
<td>mm 2.4485</td>
</tr>
<tr>
<td></td>
<td>Sericite</td>
<td>8</td>
<td>mm 2.9214</td>
</tr>
<tr>
<td></td>
<td>Pyrite</td>
<td>9</td>
<td>mm 3.4933</td>
</tr>
<tr>
<td></td>
<td>Plagioclase</td>
<td>10</td>
<td>mm 2.9040</td>
</tr>
<tr>
<td></td>
<td>Kaolin</td>
<td>11</td>
<td>mm 3.7486</td>
</tr>
<tr>
<td></td>
<td>Leucoxene</td>
<td>12</td>
<td>mm 2.8365</td>
</tr>
<tr>
<td></td>
<td>Orthoclase</td>
<td>13</td>
<td>mm 3.3688</td>
</tr>
<tr>
<td></td>
<td>Chlorite</td>
<td>14</td>
<td>mm 3.4297</td>
</tr>
<tr>
<td></td>
<td>Micaceous rock frag.</td>
<td>15</td>
<td>mm 2.7103</td>
</tr>
<tr>
<td></td>
<td>Zircon</td>
<td>16</td>
<td>mm 4.2002</td>
</tr>
<tr>
<td></td>
<td>Microcline</td>
<td>17</td>
<td>mm 3.2216</td>
</tr>
<tr>
<td></td>
<td>Limonite</td>
<td>18</td>
<td>mm 3.9748</td>
</tr>
<tr>
<td></td>
<td>Magnetite</td>
<td>19</td>
<td>mm 2.8783</td>
</tr>
<tr>
<td></td>
<td>Biotite</td>
<td>20</td>
<td>mm 2.8365</td>
</tr>
<tr>
<td></td>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total                          | 100                |    |            |

Average grain size in mm       | 0.1250             |
Average grain size in $\phi$   | 3.0643             |
Variance ($s^2$) calculated in $\phi$ | 0.2028            |
Color of rock chip             | N 6                |
APPENDIX A

Rock Type 04: Massive Gray Sandstone

Thin Section Number: 04/04
Depth Below Surface (in feet): 170.7
Core Number: G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>62</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>18</td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.1282
Average grain size in Ø: 3.0139
Variance ($s^2$) calculated in Ø: 0.1525
Color of rock chip: N6
APPENDIX A

Rock Type 04 Massive Gray Sandstone

Thin Section Number 04/05

Depth Below Surface (in feet) 242.1

Core Number G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.6336</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.2152</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.0808</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.0736</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0424</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>6. 0.0592</td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
<td>7. 0.0752</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.2496</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.1176</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.1064</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>11. 0.0992</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>2</td>
<td>12. 0.2248</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1024</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.2576</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0824</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0723</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.1504</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0408</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.1704</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1312</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.1493

Average grain size in Ø 3.0953

Variance (σ²) calculated in Ø 0.9442

Color of rock chip N 7
APPENDIX A

Rock Type 04  Massive Gray Sandstone
Thin Section Number  04/06
Depth Below Surface (in feet)  247.3
Core Number  G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1.0 0.2024   2.3047</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.0 0.1016   3.2990</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.0 0.1672   2.5804</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4.0 0.3576   1.4836</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.0 0.2744   1.8656</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6.0 0.1008   3.3104</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.0 0.1048   3.2543</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0 0.3216   1.6367</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9.0 0.0704   3.8283</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0 0.1192  3.0685</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>11.0 0.0984  3.3452</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0 0.1616  2.6295</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0 0.1816  2.4612</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0 0.0936  3.4173</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0 0.1384  2.8531</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0 0.2072  2.2709</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0 0.0744  3.7486</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0 0.1128  3.1482</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>19.0 0.1240  3.0116</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>20.0 0.1064  3.2324</td>
</tr>
</tbody>
</table>

Total  100

Average grain size in mm  0.1559
Average grain size in Ø  2.8375
Variance (σ²) calculated in Ø  0.4436
Color of rock chip  N 7
APPENDIX A

Rock Type 04

Massive Gray Sandstone

Thin Section Number

04/07

Depth Below Surface (in feet)

252.3

Core Number

G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.1232</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1128</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.0992</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4. 0.2864</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.1152</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>6. 0.2152</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0648</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.1216</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9. 0.2792</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>10. 0.1384</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.1696</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.1608</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1736</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td>14. 0.1448</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0856</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0920</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.2176</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1384</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>19. 0.1936</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>20. 0.0832</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.1508

Average grain size in Ø 2.8415

Variance (s²) calculated in Ø 0.3394

Color of rock chip N 7
APPENDIX A

Rock Type 04  Massive Gray Sandstone

Thin Section Number  04/08

Depth Below Surface (in feet)  256.0

Core Number  G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quarts</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Clear quarts</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td>1. 0.2038</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>2. 0.0832</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.0520</td>
</tr>
<tr>
<td>Silica cement</td>
<td>5</td>
<td>4. 0.0696</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5. 0.2144</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.2352</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.1344</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8. 0.2232</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>9. 0.0984</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10. 0.1688</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11. 0.4648</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.1776</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.3064</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.1272</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15. 0.1112</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0832</td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td>17. 0.5736</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.1168</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.5392</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.2216</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.2105
Average grain size in Ø   2.5619
Variance (s²) calculated in Ø  0.9310
Color of rock chip        N 7


APPENDIX A

Rock Type 04  
Massive Gray Sandstone

Thin Section Number  
04/09

Depth Below Surface (in feet)  
146.4

Core Number  
G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>79</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>4</td>
<td>1. 0.1576</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1672</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.2304</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.1824</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.3856</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1872</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0888</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.1984</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9. 0.1640</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>10. 0.1224</td>
</tr>
<tr>
<td>Leucosome</td>
<td>-</td>
<td>11. 0.0696</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.1504</td>
</tr>
<tr>
<td>Chlorite</td>
<td>2</td>
<td>13. 0.4584</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.2336</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.2208</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.2160</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.4256</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.2312</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.2712</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1368</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  
0.2149

Average grain size in Ø  
2.3682

Variance (σ²) calculated in Ø  
0.4627

Color of rock chip  
N 7
APPENDIX A

Rock Type 04  
Massive Gray Sandstone

Thin Section Number 04/10

Depth Below Surface (in feet) 149.0

Core Number G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>87</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td>Ø</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1.0 0.1968</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.0 0.2792</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.0 0.2744</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>4.0 0.2600</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.0 0.1504</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6.0 0.2224</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.0 0.2256</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0 0.4304</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>3</td>
<td>9.0 0.1128</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>10.0 0.3536</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.0 0.3992</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0 0.5664</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0 0.3640</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0 0.2928</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0 0.2168</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0 0.1592</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0 0.2744</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0 0.3672</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.0 0.4176</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0 0.1640</td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.2864
Average grain size in Ø 1.9160
Variance (s^2) calculated in Ø 0.3526
Color of rock chip N 7
## APPENDIX A

Rock Type 04  | Massive Gray Sandstone
---|---
Thin Section Number  | 04/11
Depth Below Surface (in feet)  | 152.6
Core Number  | G-3

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>79</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.1776</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1368</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3. 0.2024</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.1328</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.1024</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1208</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.4896</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0464</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>9. 0.1832</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.1944</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.2568</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.2016</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.2584</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>1</td>
<td>14. 0.1984</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.9672</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.3528</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.4472</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.3992</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>19. 0.2232</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1416</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.2616
Average grain size in $\phi$: 2.2384
Variance ($s^2$) calculated in $\phi$: 0.8870
Color of rock chip: N 7
APPENDIX A

**Rock Type** 04  
**Massive Gray Sandstone**

**Thin Section Number**  
04/12

**Depth Below Surface (in feet)**  
154.1

**Core Number**  
G-8

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Illite-Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0904</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1368</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.0976</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.0632</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.1432</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1720</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>7. 0.1792</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.3024</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>9. 0.1464</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0872</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.2432</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.4864</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0896</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.1112</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.1912</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.3384</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.1128</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1672</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>19. 0.1304</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1376</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 100

Average grain size in mm: 0.1713

Average grain size in Ø: 2.7363

Variance (σ²) calculated in Ø: 0.5312

Color of rock chip: N6
APPENDIX A

Rock Type 04
Massive Gray Sandstone

Thin Section Number 04/13

Depth Below Surface (in feet) 158.0

Core Number G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Illite-Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td>1.0.1832</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td></td>
<td>2.0.2576</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3.0.3184</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td>4.0.1656</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5.0.1976</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6.0.2184</td>
</tr>
<tr>
<td>Sericite</td>
<td>3</td>
<td>7.0.2312</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8.0.1488</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9.0.2064</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10.0.1160</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11.0.1024</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12.0.2160</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13.0.0712</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14.0.1224</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15.0.0952</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16.0.3776</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17.0.1144</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18.0.2552</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19.0.1344</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20.0.1592</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.1846
Average grain size in Ø 2.5607
Variance (s²) calculated in Ø 0.3821
Color of rock chip N 6
APPENDIX A

Rock Type 04  Massive Gray Sandstone

Thin Section Number 04/14

Depth Below Surface (in feet) 158.6

Core Number G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>66</td>
<td>0.1848</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td>0.1224</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>13</td>
<td>0.1032</td>
</tr>
<tr>
<td>Illite</td>
<td>18</td>
<td>0.1144</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>0.0934</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>0.0432</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>0.2072</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.2864</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>0.1360</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>0.1784</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>0.1656</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.3952</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>0.1408</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.0496</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>0.0728</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.3936</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.3464</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>0.1840</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>0.0496</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>0.0728</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>0.3464</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>0.1840</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td>0.0496</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td>0.1232</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.1698
Average grain size in $\phi$  2.8368
Variance ($s^2$) calculated in $\phi$  0.8904

Color of rock chip N 6
**APPENDIX A**

**Rock Type 04**  
**Massive Gray Sandstone**

**Thin Section Number**  
04/15

**Depth Below Surface (in feet)**  
162.1

**Core Number**  
G-8

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>63</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>22</td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
</tr>
<tr>
<td>Orthoelase</td>
<td>12</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
</tbody>
</table>

**Grain Size**

<table>
<thead>
<tr>
<th>Average grain size in mm</th>
<th>0.1752</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average grain size in Ø</td>
<td>2.7720</td>
</tr>
<tr>
<td>Variance (s²) calculated in Ø</td>
<td>0.8035</td>
</tr>
<tr>
<td>Color of rock chip</td>
<td>N 6</td>
</tr>
</tbody>
</table>
**APPENDIX A**

Rock Type 04: Massive Gray Sandstone

Thin Section Number: 04/16

Depth Below Surface (in feet): 164.3

Core Number: G-8

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.4268

Average grain size in $\varnothing$: 2.0998

Variance ($s^2$) calculated in $\varnothing$: 1.6650

Color of rock chip: No
## APPENDIX A

**Rock Type 04**

**Massive Gray Sandstone**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>04/17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>167.2</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-3</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>9</td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>4</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td>2</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>3</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

### Grain Size

- **Average grain size in mm**: 0.1756
- **Average grain size in Ø**: 2.7828
- **Variance (s²) calculated in Ø**: 0.7514
- **Color of rock chip**: N 6
# APPENDIX A

**Rock Type 05**  
**Bedded Gray Sandstone**

**Thin Section Number**  
05/01

**Depth Below Surface (in feet)**  
149.5

**Core Number**  
G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.1432</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>2. 0.0720</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.1368</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.0976</td>
</tr>
<tr>
<td>Calcite</td>
<td>8</td>
<td>5. 0.1064</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6. 0.1320</td>
</tr>
<tr>
<td>Sericite</td>
<td>5</td>
<td>7. 0.0760</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0880</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0864</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.1840</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.1352</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.1176</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1264</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0904</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0888</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.2024</td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td>17. 0.1072</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1016</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0800</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1464</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  
0.1159

Average grain size in \( \phi \)  
3.1670

Variance (\( s^2 \)) calculated in \( \phi \)  
0.1714

Color of rock chip  
N 6
APPENDIX a

Rock Type 05
Bedded Gray Sandstone

Thin Section Number: 05/02
Depth Below Surface (in feet): 155.4
Core Number: G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1.0824</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>0.0560</td>
</tr>
<tr>
<td>Muscovite</td>
<td>7</td>
<td>0.1008</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>0.1528</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>0.1056</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>0.1504</td>
</tr>
<tr>
<td>Sericite</td>
<td>5</td>
<td>0.0792</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>0.1424</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td>0.0720</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>0.0904</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>0.0976</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>1</td>
<td>0.1448</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>0.0784</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>0.0656</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>0.1120</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>0.0712</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>0.0616</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>0.1264</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>0.1368</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>0.1032</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.1015
Average grain size in $\phi$: 3.3680
Variance ($s^2$) calculated in $\phi$: 0.2072
Color of rock chip: N6
APPENDIX A

Rock Type 05  Bedded Gray Sandstone

Thin Section Number  05/03
Depth Below Surface (in feet)  165.3
Core Number  G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
<th>mm</th>
<th>Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td></td>
<td></td>
<td>Ø</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
<td></td>
<td>Ø</td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>1. 0.1456</td>
<td>2.7799</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>2. 0.0640</td>
<td>3.9658</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>3. 0.1640</td>
<td>2.6082</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4. 0.0872</td>
<td>3.5195</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>5. 0.1112</td>
<td>3.1638</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>4</td>
<td>6. 0.1734</td>
<td>2.4868</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>7. 0.0848</td>
<td>3.5598</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.1216</td>
<td>3.0398</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>9. 0.1048</td>
<td>3.2543</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>3</td>
<td>10. 0.0888</td>
<td>3.4933</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.1616</td>
<td>2.6295</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0664</td>
<td>3.9127</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0992</td>
<td>3.3333</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0672</td>
<td>3.8954</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.1272</td>
<td>2.9748</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.1464</td>
<td>2.7720</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td>17. 0.0952</td>
<td>3.3929</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td>18. 0.0808</td>
<td>3.6295</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.1792</td>
<td>2.4804</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>1</td>
<td>20. 0.0864</td>
<td>3.5328</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.1130
Average grain size in Ø  3.2215
Variance (s²) calculated in Ø  0.2305
Color of rock chip  N 6
## APPENDIX A

### Rock Type 05

**Bedded Gray Sandstone**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>05/04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>201.0</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>1.0456</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2.0664</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3.0504</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td>4.0432</td>
</tr>
<tr>
<td>Calcite</td>
<td>9</td>
<td>5.0720</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6.0736</td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
<td>7.0624</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0704</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>9.0792</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0936</td>
</tr>
<tr>
<td>Leucocene</td>
<td>1</td>
<td>11.0464</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0848</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>13.0656</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0520</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0816</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0888</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0688</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0896</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.1048</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0664</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

### Summary

- **Average grain size in mm**: 0.0703
- **Average grain size in φ**: 3.8740
- **Variance (s²) calculated in φ**: 0.1353
- **Color of rock chip**: N 6
APPENDIX A

Rock Type 05  Bedded Gray Sandstone

Thin Section Number 05/05
Depth Below Surface (in feet) 220.3
Core Number 0-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>52</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0984  3.3452</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>2. 0.0816  3.6153</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.1080  3.2109</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4. 0.0336  4.8954</td>
</tr>
<tr>
<td>Calcite</td>
<td>18</td>
<td>5. 0.0584  4.0979</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6. 0.1024  3.2877</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.0440  4.5064</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8. 0.0576  4.1178</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9. 0.0664  3.9127</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1</td>
<td>10. 0.0752 3.7331</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11. 0.0808 3.6295</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.0664 3.9127</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.1392 2.8448</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.0568 4.1380</td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td>15. 0.0352 4.8283</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0816 3.6153</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17. 0.0424 4.5598</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.0600 4.0589</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.0536 4.2216</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.0712 3.8120</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0706
Average grain size in $\phi$ 3.9172
Variance ($s^2$) calculated in $\phi$ 0.2876
Color of rock chip M 6
APPENDIX A

Rock Type 05    Bedded Gray Sandstone

Thin Section Number      05/06
Depth Below Surface (in feet)    122.2
Core Number             G-8

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in \( \phi \)   4.1280
Variance \((s^2)\) calculated in \( \phi \)   0.1121
Color of rock chip   N 6
APPENDIX A

Rock Type 05 Bedded Gray Sandstone

Thin Section Number 05/07
Depth Below Surface (in feet) 124.8
Core Number G-8

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>47</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td>$\phi$</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>1.00564</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td>2.00710</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3.00362</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4.00376</td>
</tr>
<tr>
<td>Calcite</td>
<td>7</td>
<td>5.00718</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6.00526</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>7.00370</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8.00338</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9.00516</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10.00284</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11.00300</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12.00544</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13.00218</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14.00542</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15.00474</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16.00622</td>
</tr>
<tr>
<td>Limonite</td>
<td>1</td>
<td>17.00326</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18.00696</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19.00454</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20.00466</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0470
Average grain size in $\phi$ 4.4825
Variance ($s^2$) calculated in $\phi$ 0.2294
Color of rock chip N 6
## APPENDIX A

### Rock Type 05

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>05/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>127.6</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-3</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>32</td>
<td>0.0454, 4.4612</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td>0.0188, 5.7331</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>24</td>
<td>0.0660, 3.9214</td>
</tr>
<tr>
<td>Siderite</td>
<td>7</td>
<td>0.0436, 4.5195</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>0.0182, 5.7799</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>0.0356, 4.8120</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>0.0182, 5.7799</td>
</tr>
<tr>
<td>Calcite</td>
<td>13</td>
<td>0.0660, 3.9214</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>0.0208, 5.5873</td>
</tr>
<tr>
<td>Sericite</td>
<td>3</td>
<td>0.0386, 4.6953</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>0.0208, 5.5873</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>0.0426, 4.5530</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>0.0388, 4.6878</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>2</td>
<td>0.0204, 5.6153</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>0.0228, 5.4548</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.0282, 5.1482</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.0388, 4.6878</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.0508, 4.2990</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.0604, 4.0493</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>0.0478, 4.3868</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.0224, 5.4804</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.0542, 4.2056</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.0460, 4.4422</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm: 0.0380**

**Average grain size in Ø: 4.8260**

**Variance (s^2) calculated in Ø: 0.3497**

**Color of rock chip: N 6**
**APPENDIX A**

**Rock Type 05**  
**Bedded Gray Sandstone**

**Thin Section Number**  
05/09

**Depth Below Surface (in feet)**  
143.9

**Core Number**  
G-8

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1.0.0442</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2.0.0538</td>
</tr>
<tr>
<td>Muscovite</td>
<td>10</td>
<td>3.0.0236</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4.0.0498</td>
</tr>
<tr>
<td>Calcite</td>
<td>2</td>
<td>5.0.0754</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6.0.0398</td>
</tr>
<tr>
<td>Sericite</td>
<td>5</td>
<td>7.0.0636</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0.0446</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>9.0.0856</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0.0650</td>
</tr>
<tr>
<td>Leucosane</td>
<td>-</td>
<td>11.0.0984</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0.0282</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0.0516</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0.0476</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0.0508</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0.0724</td>
</tr>
<tr>
<td>Limestone</td>
<td>-</td>
<td>17.0.0418</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0.0506</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.0.0538</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0.0386</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.0540

**Average grain size in ø**  
4.2913

**Variance (s²) calculated in ø**  
0.2472

**Color of rock chip**  
N 6
## APPENDIX A

**Rock Type 05**

**Bedded Gray Sandstone**

**Thin Section Number**

05/10

**Depth Below Surface (in feet)**

67.5

**Core Number**

G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.1448</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1840</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3. 0.5000</td>
</tr>
<tr>
<td>Silica cement</td>
<td>6</td>
<td>4. 0.0792</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.1896</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>6. 0.2568</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.1552</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.2256</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>3</td>
<td>9. 0.1928</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.1496</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.2504</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.3504</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.1504</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.2376</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.3408</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.1464</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.3528</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.1128</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.4560</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.1936</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.2334

Average grain size in Ø: 2.2498

Variance (s²) calculated in Ø: 0.4575

Color of rock chip: 3 YR 6/1
## APPENDIX A

Rock Type 06  Pebbly Gray Sandstone

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>06/01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>86.2</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Leucocene</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 100

Average grain size in mm 0.1968
Average grain size in $\phi$ 2.5479
Variance ($s^2$) calculated in $\phi$ 0.6695
Color of rock chip 5 YR 5 1/2
APPENDIX A

Rock Type 06 Pebbly Gray Sandstone

Thin Section Number 06/02

Depth Below Surface (in feet) 85.7

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.2138

Average grain size in Ø 2.5175

Variance (s^2) calculated in Ø 0.8590

Color of rock chip 5 YR 5 1/2
### APPENDIX A

**Rock Type 07**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>07/01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>113.2</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1.00</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2.00</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3.00</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4.00</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.00</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>6.00</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.00</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.00</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9.00</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.00</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.00</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.00</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.00</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.00</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.00</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.00</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.00</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.00</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.00</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.00</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Total: 100

**Average grain size in mm**

|            | 3.1946 |

**Average grain size in $\phi$**

|            | -0.9828 |

**Variance ($s^2$) calculated in $\phi$**

|            | 3.2309 |

**Color of rock chip**

|            | N 7    |
### APPENDIX A

**Rock Type 07**

**Conglomerate**

**Thin Section Number**

07/02

**Depth Below Surface (in feet)**

114.0

**Core Number**

G-9

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>-</td>
<td>mm</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 1.7010</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>2. 0.1562</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>3. 4.8811</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.8442</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.9031</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 2.4063</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.5713</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 5.0011</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 3.4251</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>2</td>
<td>10. 3.9691</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.4221</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.8764</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 1.2903</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.6571</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 1.5381</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 5.0672</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 3.8042</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 3.5194</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 3.4830</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 2.2353</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 100

- **Average grain size in mm**: 2.3376
- **Average grain size in Ø**: -0.7262
- **Variance (s²) calculated in Ø**: 1.9388
- **Color of rock chip**: N 6
APPENDIX A

Rock Type 08  
Massive Shale

Thin Section Number  
08/01

Depth Below Surface (in feet)  
160.2

Core Number  
G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>5</td>
<td>0.0462 4.4360</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td>0.0350 4.8365</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>75</td>
<td>0.0598 4.0637</td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td>0.0226 5.4675</td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>0.0342 4.8699</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>0.0584 4.0979</td>
</tr>
<tr>
<td>Muscovite</td>
<td>-</td>
<td>0.0306 5.0303</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>0.0242 5.3688</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>0.0416 4.5873</td>
</tr>
<tr>
<td>Chert</td>
<td>1</td>
<td>0.0204 5.6153</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>0.0186 5.7486</td>
</tr>
<tr>
<td>Pyrite</td>
<td>7</td>
<td>0.0296 5.0783</td>
</tr>
<tr>
<td>Pegmatite</td>
<td>-</td>
<td>0.0198 5.6584</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>0.0050 4.1844</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>0.0324 4.9479</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>0.0162 5.9479</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.0506 4.3047</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.0384 4.7027</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.0354 4.8201</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.3511</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>4.9339</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.3183</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>N 3</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.3511

Average grain size in $\phi$ 4.9339

Variance ($s^2$) calculated in $\phi$ 0.3183

Color of rock chip N 3
## APPENDIX A

### Rock Type 08

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>Depth Below Surface (in feet)</th>
<th>Core Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/02</td>
<td>162.2</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td>1.0.0412</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>2.0.0128</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3.0.0144</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4.0.0362</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5.0.0162</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6.0.0158</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7.0.0256</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8.0.0312</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9.0.0476</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10.0.0364</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11.0.0296</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12.0.0262</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13.0.0132</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14.0.0398</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15.0.0456</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16.0.0178</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17.0.0194</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18.0.0530</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19.0.0202</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20.0.0214</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm        0.2818
Average grain size in $\phi$     5.2892
Variance ($s^2$) calculated in $\phi$     0.4341
Color of rock chip              N 3
APPENDIX A

Rock Type 09 | Disturbed Structure Shale
---|---
Thin Section Number | 09/01
Depth Below Surface (in feet) | 118.3
Core Number | G-9

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quarts</td>
<td>3</td>
<td>0.0296</td>
</tr>
<tr>
<td>Clear quarts</td>
<td>7</td>
<td>0.0166</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>83</td>
<td>0.0118</td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td>0.0158</td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>0.0492</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>0.0194</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>0.0148</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>0.0166</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>0.0252</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>0.0118</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>0.0206</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>0.0362</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>0.0238</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>0.0564</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>0.0108</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>0.0146</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>0.0362</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>0.0238</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>0.0066</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>0.0096</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>0.0334</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>0.0188</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.0418</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>0.0238</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>0.0096</td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.0238
Average grain size in Ø 5.6022
Variance (s²) calculated in Ø 0.6554
Color of rock chip N 3
APPENDIX A

Rock Type 09   Disturbed Structure Shale

Thin Section Number       09/02
Depth Below Surface (in feet)  119.1
Core Number               G-9

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm           0.0364
Average grain size in $\phi$       4.9503
Variance ($\sigma^2$) calculated in $\phi$ 0.5514
Color of rock chip               W 5
## APPENDIX A

Rock Type 09  Disturbed Structure Shale

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>09/03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>119.9</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>16</td>
<td>1. 0.0204  5.6153</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2</td>
<td>2. 0.0438  4.5129</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>3. 0.0558  4.1636</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.0296  5.0783</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.0638  3.9703</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.1188  3.0734</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>7. 0.0818  3.6118</td>
</tr>
<tr>
<td>Pyrite</td>
<td>17</td>
<td>8. 0.0146  6.0979</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0602  4.0541</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0550 4.1844</td>
</tr>
<tr>
<td>Leucaxene</td>
<td>-</td>
<td>11. 0.0536 4.2216</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0654 3.9346</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0478 4.3868</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0242 5.3688</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0410 4.6082</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0498 4.3277</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0638 3.5769</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0476 4.3929</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0562 4.1533</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0278 5.1688</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

| Average grain size in mm | 0.0521 |
| Average grain size in $\phi$ | 4.4251 |
| Variance ($s^2$) calculated in $\phi$ | 0.5354 |
| Color of rock chip | N 6 |
APPENDIX A

Rock Type 09  Disturbed Structure Shale

Thin Section Number  09/04

Depth Below Surface (in feet)  130.0

Core Number  G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.0283

Average grain size in Ø  5.3607

Variance (σ²) calculated in Ø  0.7303

Color of rock chip  N 5
APPENDIX A

Rock Type 09  Disturbed Structure Shale

Thin Section Number  09/05
Depth Below Surface (in feet)  131.3
Core Number  G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusty quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td>0.0806</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>6</td>
<td>0.0100</td>
</tr>
<tr>
<td>Illite</td>
<td>59</td>
<td>0.0410</td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td>0.0294</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>9</td>
<td>0.0136</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2</td>
<td>0.0378</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>0.0294</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>0.0684</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>0.0494</td>
</tr>
<tr>
<td>Sericite</td>
<td>1</td>
<td>0.0108</td>
</tr>
<tr>
<td>Pyrite</td>
<td>5</td>
<td>0.0294</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>0.0690</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>0.0198</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>0.0410</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>0.0216</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>0.0690</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>0.0198</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>0.0414</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>0.0536</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>0.0542</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>0.0274</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>0.0318</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total  100

Average grain size in mm  0.0374
Average grain size in Ø  4.9794
Variance (s²) calculated in Ø  0.8035
Color of rock chip  N 4
**APPENDIX A**

Rock Type 09  Disturbed Structure Shale

Thin Section Number  09/06

Depth Below Surface (in feet)  131.6

Core Number  G-9

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>21</td>
<td>0.0314</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>6</td>
<td>0.0304</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>23</td>
<td>0.0128</td>
</tr>
<tr>
<td>Illite</td>
<td>24</td>
<td>0.0176</td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>0.0202</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>4</td>
<td>0.0930</td>
</tr>
<tr>
<td>Muscovite</td>
<td>11</td>
<td>0.0722</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>0.0082</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>0.0114</td>
</tr>
<tr>
<td>Chert</td>
<td>2</td>
<td>0.0238</td>
</tr>
<tr>
<td>Sericite</td>
<td>3</td>
<td>0.0108</td>
</tr>
<tr>
<td>Pyrite</td>
<td>4</td>
<td>0.0146</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>0.0304</td>
</tr>
<tr>
<td>Kaolin</td>
<td>5</td>
<td>0.0268</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>0.0438</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.0266</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.0348</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>0.0508</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>0.0382</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>0.0106</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>0.0106</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>0.0106</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td>0.0106</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td>0.0106</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm  0.0304

Average grain size in ø  5.3433

Variance (s^2) calculated in ø  0.9091

Color of rock chip  N 5
### APPENDIX A

**Rock Type 09**
**Disturbed Structure Shale**

**Thin Section Number**
09/07

**Depth Below Surface (in feet)**
131.9

**Core Number**
G-9

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Composition</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5</td>
<td>mm</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0126</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>4</td>
<td>2. 0.0658</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.0064</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
<td>4. 0.0396</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>5. 0.0188</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
<td>6. 0.0716</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>7. 0.0198</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8. 0.0096</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>9. 0.0216</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>10. 0.0086</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>11. 0.0526</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>12. 0.0552</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>13. 0.0684</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>14. 0.0218</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>15. 0.0428</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>16. 0.0256</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>17. 0.0296</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>18. 0.0186</td>
</tr>
<tr>
<td>Rutilite</td>
<td>19</td>
<td>19. 0.0116</td>
</tr>
<tr>
<td>Garnet</td>
<td>20</td>
<td>20. 0.0416</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**
0.0321

**Average grain size in Ø**
5.2985

**Variance (σ²) calculated in Ø**
1.1234

**Color of rock chip**
N 4
APPENDIX A

Rock Type 09
Disturbed Structure Shale

Thin Section Number 09/08
Depth Below Surface (in feet) 140.8
Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0298</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>2. 0.0462</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.0168</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.0518</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.0338</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0436</td>
</tr>
<tr>
<td>Sericite</td>
<td>3</td>
<td>7. 0.0396</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>8. 0.0342</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0568</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0598</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0456</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0734</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0118</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0406</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0204</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0474</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0564</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0202</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0290</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0436</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0400
Average grain size in Ø 4.7738
Variance (s²) calculated in Ø 0.4561
Color of rock chip N 4
### APPENDIX A

Rock Type 09  
**Disturbed Structure Shale**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>09/09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>169.8</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>19</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>48</td>
</tr>
<tr>
<td>Illite</td>
<td>4</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
</tr>
<tr>
<td>Muscovite</td>
<td>8</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
</tr>
<tr>
<td>Garnet</td>
<td>20</td>
</tr>
</tbody>
</table>

| Total | 100 |

### Grain Size

- **Average grain size in mm**: 0.0357
- **Average grain size in Ø**: 4.8853
- **Variance (s²) calculated in Ø**: 0.2401
- **Color of rock chip**: N 5
APPENDIX A

Rock Type 09  Disturbed Structure Shale

Thin Section Number  09/10
Depth Below Surface (in feet)  180.9
Core Number  G-9

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quarts</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0456</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>2. 0.0254</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3. 0.0292</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0194</td>
</tr>
<tr>
<td>Calcite</td>
<td>4</td>
<td>5. 0.0562</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0246</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0198</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0216</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0312</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0196</td>
</tr>
<tr>
<td>Leucocxene</td>
<td>1</td>
<td>11. 0.0384</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0306</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0246</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0316</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0282</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0126</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0372</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0118</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0358</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0530</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in **= 0.0298**

Average grain size in Ø = 5.1810

Variance (s²) calculated in Ø = 0.3592

Color of rock chip = N 5
APPENDIX A

Rock Type 09                  Disturbed Structure Shale
Thin Section Number           09/11
Depth Below Surface (in feet)  133.7
Core Number                   G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>16</td>
<td>1. 0.0710</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td>2. 0.0646</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>28</td>
<td>3. 0.0430</td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td>4. 0.0624</td>
</tr>
<tr>
<td>Siderite</td>
<td>23</td>
<td>5. 0.0444</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
<td>6. 0.0306</td>
</tr>
<tr>
<td>Muscovite</td>
<td>6</td>
<td>7. 0.0142</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>8. 0.0206</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
<td>9. 0.0198</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>10. 0.0456</td>
</tr>
<tr>
<td>Sericite</td>
<td>3</td>
<td>11. 0.0370</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>12. 0.0528</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>13. 0.0436</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>14. 0.0498</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>1</td>
<td>15. 0.0298</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>16. 0.0442</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>17. 0.0456</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>18. 0.0218</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>19. 0.0190</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>20. 0.0226</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm     0.0391
Average grain size in φ        4.8131
Variance (s²) calculated in φ  0.4486
Color of rock chip             N 6
# APPENDIX A

**Rock Type 10**  
**Graded Bedding Shale**

**Thin Section Number**  
10/01

**Depth Below Surface (in feet)**  
173.3

**Core Number**  
G-9

## Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1.0144</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2.0216</td>
</tr>
<tr>
<td>Muscovite</td>
<td>6</td>
<td>3.0246</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4.0190</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5.0316</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6.0110</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7.0142</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8.0256</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9.0144</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10.0162</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11.0114</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12.0100</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13.0254</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14.0158</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15.0340</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16.00296</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17.00218</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18.0198</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19.0336</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20.0376</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.0216

**Average grain size in Ø**  
5.6410

**Variance ($s^2$) calculated in Ø**  
0.3360

**Color of rock chip**  
N 4
### APPENDIX A

**Rock Type 10**

**Graded Bedding Shale**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>10/02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>175.5</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1. 0.0166</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2. 0.0114</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>3. 0.0138</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0156</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0184</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0518</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0436</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0268</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0226</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0384</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0252</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0102</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0306</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0226</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0314</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0196</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0146</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0194</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0306</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0208</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in **mm** 0.0242  
Average grain size in $\phi$ 5.4994  
Variance ($s^2$) calculated in $\phi$ 0.3927  
Color of rock chip N 5
APPENDIX A

Rock Type 10  Graded Bedding Shale

Thin Section Number 10/03

Depth Below Surface (in feet) 185.2

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0308

Average grain size in Ø 5.1292

Variance (s²) calculated in Ø 0.3550

Color of rock chip N 4
## APPENDIX A

**Rock Type 10**  
*Graded Bedding Shale*

**Thin Section Number**  
10/04

**Depth Below Surface (in feet)**  
186.2

**Core Number**  
G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>1. 0.0224</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
<td>2. 0.0316</td>
</tr>
<tr>
<td>Muscovite</td>
<td>8</td>
<td>3. 0.0256</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0366</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0108</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0278</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0384</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0386</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0214</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0426</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0280</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0428</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0318</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0586</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0346</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0204</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0318</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0186</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>19. 0.0198</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>20. 0.0166</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.0299

**Average grain size in Ø**  
5.1629

**Variance (s²) calculated in Ø**  
0.3250

**Color of rock chip**  
N 4
APPENDIX A

Rock Type 10 Graded Bedding Shale

Thin Section Number 10/05

Depth Below Surface (in feet) 202.9

Core Number 0-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td>1. 0.0202</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
<td>2. 0.0158</td>
</tr>
<tr>
<td>Muscovite</td>
<td>6</td>
<td>3. 0.0166</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4. 0.0486</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5. 0.0260</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.0106</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.0336</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td>8. 0.0306</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9. 0.0376</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10. 0.0262</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11. 0.0442</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.0344</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.0380</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.0262</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15. 0.0178</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0198</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17. 0.0314</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.0366</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.0408</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.0218</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0286

Average grain size in Ø 5.2317

Variance (s^2) calculated in Ø 0.3365

Color of rock chip N 4
## APPENDIX A

**Rock Type 10**  
**Graded Bedding Shale**

**Thin Section Number**  
10/06

**Depth Below Surface (in feet)**  
205.9

**Core Number**  
G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>1</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>18</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>40</td>
</tr>
<tr>
<td>Illite</td>
<td>28</td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>10</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
</tr>
<tr>
<td>Silica cement</td>
<td>4</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
</tr>
<tr>
<td>Chert</td>
<td>6</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
</tr>
<tr>
<td>Biotite</td>
<td>19</td>
</tr>
<tr>
<td>Rutile</td>
<td>20</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grain Size</th>
<th>mm</th>
<th>ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0224</td>
<td>1</td>
<td>5.4804</td>
</tr>
<tr>
<td>0.0106</td>
<td>2</td>
<td>6.5598</td>
</tr>
<tr>
<td>0.0136</td>
<td>3</td>
<td>6.2002</td>
</tr>
<tr>
<td>0.0064</td>
<td>4</td>
<td>7.2877</td>
</tr>
<tr>
<td>0.0166</td>
<td>5</td>
<td>5.9127</td>
</tr>
<tr>
<td>0.0264</td>
<td>6</td>
<td>5.2433</td>
</tr>
<tr>
<td>0.0246</td>
<td>7</td>
<td>5.3452</td>
</tr>
<tr>
<td>0.0202</td>
<td>8</td>
<td>5.6295</td>
</tr>
<tr>
<td>0.0224</td>
<td>9</td>
<td>5.4804</td>
</tr>
<tr>
<td>0.0166</td>
<td>10</td>
<td>5.9127</td>
</tr>
<tr>
<td>0.0374</td>
<td>11</td>
<td>4.7408</td>
</tr>
<tr>
<td>0.0180</td>
<td>12</td>
<td>5.7959</td>
</tr>
<tr>
<td>0.0144</td>
<td>13</td>
<td>6.1178</td>
</tr>
<tr>
<td>0.0172</td>
<td>14</td>
<td>5.8614</td>
</tr>
<tr>
<td>0.0324</td>
<td>15</td>
<td>4.9479</td>
</tr>
<tr>
<td>0.0222</td>
<td>16</td>
<td>5.4933</td>
</tr>
<tr>
<td>0.0318</td>
<td>17</td>
<td>4.9748</td>
</tr>
<tr>
<td>0.0300</td>
<td>18</td>
<td>5.0589</td>
</tr>
<tr>
<td>0.0198</td>
<td>19</td>
<td>5.6584</td>
</tr>
<tr>
<td>0.0260</td>
<td>20</td>
<td>5.2653</td>
</tr>
</tbody>
</table>

**Average grain size in mm**  
0.0215

**Average grain size in ø**  
5.6483

**Variance (s²) calculated in ø**  
0.3605

**Color of rock chip**  
N 4
APPENDIX A

Rock Type 10 Graded Bedding Shale

Thin Section Number 10/07

Depth Below Surface (in feet) 214.4

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1. 0.0186</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>2. 0.0284</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>3. 0.0122</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4. 0.0124</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5. 0.0204</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.0124</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.0302</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8. 0.0326</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9. 0.0182</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10. 0.0280</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11. 0.0246</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.0282</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.0266</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.0316</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15. 0.0176</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0144</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17. 0.0258</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.0242</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.0102</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.0278</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0222
Average grain size in $\phi$ 5.5769
Variance ($s^2$) calculated in $\phi$ 0.2800
Color of rock chip 4
# APPENDIX A

## Rock Type 10

**Graded Bedding Shale**

**Thin Section Number**: 10/08  
**Depth Below Surface (in feet)**: 216.5  
**Core Number**: G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>18</td>
<td>5.8448</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td>5.4804</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>62</td>
<td>5.9127</td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td>5.6730</td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>5.3929</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1</td>
<td>5.6730</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>5.3929</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>5.6730</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>5.3929</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>5.3929</td>
</tr>
</tbody>
</table>

**Total**: 100

**Average grain size in mm**: 0.0276  
**Average grain size in \(\phi\)**: 5.2442  
**Variance (\(s^2\)) calculated in \(\phi\)**: 0.1929  
**Color of rock chip**: N 4
APPENDIX A

Rock Type 10          Graded Bedding Shale
Thin Section Number   10/09
Depth Below Surface (in feet)  225.0
Core Number           G-9

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Rutilite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in \( \text{\mu m} \)          0.0220
Average grain size in \( \phi \)                  5.5567
Variance \( (s^2) \) calculated in \( \phi \)     0.1486
Color of rock chip                           N 4
APPENDIX A

Rock Type 10 Graded Bedding Shale

Thin Section Number 10/10

Depth Below Surface (in feet) 231.4

Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0150</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td>2. 0.0142</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3. 0.0152</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0258</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0200</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0154</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0144</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0214</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0126</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0192</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0498</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0094</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0296</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0292</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0262</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0126</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0238</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0174</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>19. 0.0170</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0208

Average grain size in $\phi$ 5.6960

Variance ($s^2$) calculated in $\phi$ 0.3166

Color of rock chip N 4
APPENDIX A

Rock Type 10  Graded Bedding Shale

Thin Section Number  10/11

Depth Below Surface (in feet)  231.5

Core Number  G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0204</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2. 0.0146</td>
</tr>
<tr>
<td>Muscovite</td>
<td>7</td>
<td>3. 0.0164</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0330</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.0186</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0156</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0136</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0244</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0142</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0260</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0258</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0146</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>13. 0.0106</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0150</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0366</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0082</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0296</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0158</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0150</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0098</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.0169
Average grain size in Ø   5.8383
Variance (s²) calculated in Ø  0.3372
Color of rock chip        N 4
## APPENDIX A

**Rock Type 11**

*Mixed Disturbed Structure and Graded Bedding Shale*

**Thin Section Number** 11/01

**Depth Below Surface (in feet)** 135.8

**Core Number** G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>4</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>46</td>
<td>1. 0.0224  5.4804</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2. 0.0242  5.3688</td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td>3. 0.0824  3.6012</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4. 0.0166  5.9127</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5. 0.0114  6.4548</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.0486  4.3629</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.0118  6.4051</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8. 0.1436  2.7999</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9. 0.0166  5.9127</td>
</tr>
<tr>
<td>Kaolinite</td>
<td></td>
<td>10. 0.0206 5.6012</td>
</tr>
<tr>
<td>Leucocene</td>
<td>1</td>
<td>11. 0.1138 3.1354</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.0338 4.8868</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.0276 5.1792</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.0216 5.5328</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15. 0.0314 4.9931</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0206 5.6012</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17. 0.2536 1.9794</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.0154 6.0209</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.0164 5.9302</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.0306 5.0303</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm

0.0482

Average grain size in $\phi$

5.0094

Variance ($s^2$) calculated in $\phi$

1.5203

Color of rock chip

N 5
APPENDIX A

Rock Type 11
Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/02
Depth Below Surface (in feet) 139.7
Core Number G-9

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>5</td>
<td>1. 0.0518  4.2709</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2. 0.0416  4.5873</td>
</tr>
<tr>
<td>Muscovite</td>
<td>9</td>
<td>3. 0.0386  4.6953</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1</td>
<td>4. 0.0188  5.7331</td>
</tr>
<tr>
<td>Calcite</td>
<td>5</td>
<td>5. 0.0232  5.4297</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0284  5.1300</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0806  3.6331</td>
</tr>
<tr>
<td>Pyrite</td>
<td>12</td>
<td>8. 0.0324  4.9479</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0098  6.6730</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0156 6.0023</td>
</tr>
<tr>
<td>Leucosaxxe</td>
<td>-</td>
<td>11. 0.0312 5.0023</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0300 5.0589</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0530 4.2379</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0206 5.6012</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0188 5.7331</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0246 5.3152</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0166 5.9127</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0104 6.5873</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0508 4.2990</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0682 3.8741</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0333
Average grain size in ø 5.1381
Variance (σ²) calculated in ø 0.7128
Color of rock chip N 4
Color of rock chip

0.4836
S

Permeability calculated in

Ø

Average Grain size in mm

0.0332


t


<table>
<thead>
<tr>
<th>Item</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gneiss;

Ø

Composition

Core Number

9-9

Depth Below Surface (in feet)

172.6

Total Section Number

11/03

Geologic Bedding Slope

Mixed Diastrophic Structure

Rock Type II

APPENDIX A

13
APPENDIX A

Rock Type 11: Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/04

Depth Below Surface (in feet) 191.6

Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>11</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0284</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td>2. 0.0240</td>
</tr>
<tr>
<td>Muscovite</td>
<td>8</td>
<td>3. 0.0256</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0188</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0404</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0242</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0190</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0140</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0282</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>-</td>
<td>10. 0.0246</td>
</tr>
<tr>
<td>Leucaxonite</td>
<td>-</td>
<td>11. 0.0384</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0624</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0274</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0216</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0286</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0244</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0206</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0174</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0456</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0376</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0286

Average grain size in $\varnothing$ 5.2227

Variance ($s^2$) calculated in $\varnothing$ 0.2661

Color of rock chip N 5
APPENDIX A

Rock Type 11 Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/05
Depth Below Surface (in feet) 192.3
Core Number G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0338
Average grain size in Ø 4.9477
Variance (s²) calculated in Ø 0.1733
Color of rock chip N 5
### APPENDIX A

**Rock Type 11**  
**Mixed Disturbed Structure and Graded Bedding Shale**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>11/06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>195.8</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-9</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>4</td>
<td>0.0400</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>9</td>
<td>0.0264</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>7</td>
<td>0.0556</td>
</tr>
<tr>
<td>Illite</td>
<td>1</td>
<td>0.0252</td>
</tr>
<tr>
<td>Siderite</td>
<td>6</td>
<td>0.0216</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>9</td>
<td>0.0074</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>0.0146</td>
</tr>
<tr>
<td>Silica cement</td>
<td>5</td>
<td>0.0268</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
<td>0.0172</td>
</tr>
<tr>
<td>Chert</td>
<td>7</td>
<td>0.0182</td>
</tr>
<tr>
<td>Sericite</td>
<td>8</td>
<td>0.0198</td>
</tr>
<tr>
<td>Pyrite</td>
<td>9</td>
<td>0.0294</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>10</td>
<td>0.0216</td>
</tr>
<tr>
<td>Kaolin</td>
<td>11</td>
<td>0.0140</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>12</td>
<td>0.0336</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>13</td>
<td>0.0176</td>
</tr>
<tr>
<td>Chlorite</td>
<td>14</td>
<td>0.0398</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>15</td>
<td>0.0214</td>
</tr>
<tr>
<td>Zircon</td>
<td>16</td>
<td>0.0092</td>
</tr>
<tr>
<td>Microcline</td>
<td>17</td>
<td>0.0150</td>
</tr>
<tr>
<td>Limonite</td>
<td>Garnet</td>
<td>Total</td>
</tr>
</tbody>
</table>

Average grain size in mm: 0.0232  
Average grain size in $\phi$: 5.5897  
Variance ($s^2$) calculated in $\phi$: 0.4946  
Color of rock chip: N 4
### APPENDIX A

**Rock Type 11**

**Mixed Disturbed Structure and Graded Bedding Shale**

**Thin Section Number**  
11/07

**Depth Below Surface (in feet)**  
227.5

**Core Number**  
G-9

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0124</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>2. 0.0508</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3. 0.0394</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0132</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0243</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0224</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0148</td>
</tr>
<tr>
<td>Fyrite</td>
<td>-</td>
<td>8. 0.0140</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0202</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0216</td>
</tr>
<tr>
<td>Leucocxene</td>
<td>-</td>
<td>11. 0.0182</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0218</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0208</td>
</tr>
<tr>
<td>Siliceous rock frag.</td>
<td>-</td>
<td>14. 0.0394</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0112</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0196</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0186</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0274</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0148</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0244</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Total**  
100

**Average grain size in mm**  
0.0225

**Average grain size in $\phi$**  
5.5917

**Variance ($s^2$, calculated in $\phi$)**  
0.3325

**Color of rock chip**  
N 3
## APPENDIX A

**Rock Type II** Mixed Disturbed Structure and Graded Bedding Shale

**Thin Section Number** 11/08

**Depth Below Surface (in feet)** 235.9

**Core Number** G-9

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0154</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>17</td>
<td>2. 0.0226</td>
</tr>
<tr>
<td>Muscovite</td>
<td>5</td>
<td>3. 0.0204</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0198</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0152</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0148</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0186</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0222</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0206</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0164</td>
</tr>
<tr>
<td>Leucocenisms</td>
<td>-</td>
<td>11. 0.0238</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0160</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0154</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0244</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0176</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0274</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0202</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0120</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0166</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0644</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in **mm** 0.0212

Average grain size in **Ø** 5.6644

Variance (s²) calculated in Ø 0.2485

Color of rock chip N 4
### APPENDIX A

**Rock Type II**

**Mixed Disturbed Structure and Graded Bedding Shale**

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>11/09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>110.6</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-8</td>
</tr>
</tbody>
</table>

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1. 0.0154</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5</td>
<td>2. 0.0204</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td>3. 0.0280</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4. 0.0256</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>5. 0.0386</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.0198</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>7. 0.0210</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>8. 0.0136</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>9. 0.0156</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>10. 0.0172</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>11. 0.0238</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>12. 0.0244</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>13. 0.0226</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>14. 0.0218</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>15. 0.0216</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>16. 0.0286</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>17. 0.0184</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>18. 0.0436</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>19. 0.0266</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>20. 0.0248</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm** 0.0233

**Average grain size in Ø** 5.4845

**Variance (s^2) calculated in Ø** 0.1703

**Color of rock chip** N 4
APPENDIX A

Rock Type II: Mixed Disturbed Structure and Graded Bedding Shale

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>Depth Below Surface (in feet)</th>
<th>Core Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/10</td>
<td>112.1</td>
<td>G-8</td>
</tr>
</tbody>
</table>

**Composition**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0294
Average grain size in Ø 5.1944
Variance (s^2) calculated in Ø 0.3314
Color of rock chip N 4
APPENDIX A

Rock Type 11
Mixed Disturbed Structure and
Graded Bedding Shale

Thin Section Number 11/11
Depth Below Surface (in feet) 113.0
Core Number G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1. 0.0262 5.2543</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>2. 0.0324 4.9479</td>
</tr>
<tr>
<td>Muscovite</td>
<td>8</td>
<td>3. 0.0406 4.6224</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>4. 0.0218 5.5195</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.0148 6.0783</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>6. 0.0240 5.3808</td>
</tr>
<tr>
<td>Sericite</td>
<td>7</td>
<td>0.0166 5.9127</td>
</tr>
<tr>
<td>Pyrite</td>
<td>8</td>
<td>0.0174 5.8448</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>9</td>
<td>0.0282 5.1482</td>
</tr>
<tr>
<td>Kaolin</td>
<td>10</td>
<td>0.0182 5.7799</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>11</td>
<td>0.0418 4.5804</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12</td>
<td>0.0324 4.9479</td>
</tr>
<tr>
<td>Chlorite</td>
<td>13</td>
<td>0.0164 5.9302</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>14</td>
<td>0.0268 5.2216</td>
</tr>
<tr>
<td>Zircon</td>
<td>15</td>
<td>0.0270 5.2109</td>
</tr>
<tr>
<td>Microcline</td>
<td>16</td>
<td>0.0142 6.1380</td>
</tr>
<tr>
<td>Limonite</td>
<td>17</td>
<td>0.0220 5.5064</td>
</tr>
<tr>
<td>Magnetite</td>
<td>18</td>
<td>0.0162 5.9479</td>
</tr>
<tr>
<td>Rutilie</td>
<td>19</td>
<td>0.0136 6.2002</td>
</tr>
<tr>
<td>Garnet</td>
<td>20</td>
<td>0.0274 5.1897</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in \( \text{mm} \) 0.0239
Average grain size in \( \text{\( \phi \)} \) 5.4681
Variance \( (s^2) \) calculated in \( \text{\( \phi \)} \) 0.2445
Color of rock chip N 4
### APPENDIX A

**Rock Type 11** Mixed Disturbed Structure and Graded Bedding Shale

<table>
<thead>
<tr>
<th>Thin Section Number</th>
<th>11/12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Below Surface (in feet)</td>
<td>113.5</td>
</tr>
<tr>
<td>Core Number</td>
<td>G-8</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Illite-Illite-Siderite</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0244</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6</td>
<td>2. 0.0142</td>
</tr>
<tr>
<td>Muscovite</td>
<td>12</td>
<td>3. 0.0298</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0304</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0256</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0246</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0202</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0264</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0174</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0144</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0198</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0184</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>13. 0.0346</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0246</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0238</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0134</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0146</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0178</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0298</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0188</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Average grain size in mm** 0.0222

**Average grain size in Ø** 5.5509

**Variance (s²) calculated in Ø** 0.1679

**Color of rock chip** N 4
APPENDIX A

Rock Type 11 Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/13
Depth Below Surface (in feet) 113.8
Core Number G-8

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1. 0.0174</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>2. 0.0226</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>3. 0.0158</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0206</td>
</tr>
<tr>
<td>Calcite</td>
<td>1</td>
<td>5. 0.0228</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0198</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0308</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0128</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0142</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>-</td>
<td>10. 0.0256</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0294</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0346</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0164</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0188</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0220</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0282</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0206</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0290</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0108</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0446</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0228
Average grain size in Ø 5.5366
Variance (s²) calculated in Ø 0.2566
Color of rock chip N 4
APPENDIX A

Rock Type 11  Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number  11/14
Depth Below Surface (in feet)  126.6
Core Number  G-8

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>4</td>
<td>mm</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
<td>1. 0.0214</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>2. 0.0226</td>
</tr>
<tr>
<td>Muscovite</td>
<td>7</td>
<td>3. 0.0382</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0378</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5. 0.0164</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0196</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0106</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0556</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0226</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0226</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0122</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0162</td>
</tr>
<tr>
<td>Chlorite</td>
<td>1</td>
<td>13. 0.0244</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0288</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0314</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0236</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0096</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0228</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19. 0.0174</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0212</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm  0.0237
Average grain size in $\phi$  5.5287
Variance ($s^2$) calculated in $\phi$  0.3823
Color of rock chip  M 4
APPENDIX A

Rock Type 11 Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/15
Depth Below Surface (in feet) 135.5
Core Number G-8

<table>
<thead>
<tr>
<th>Composition</th>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>9</td>
<td>1.</td>
<td>5.0685</td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>2.</td>
<td>5.6878</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>15</td>
<td>3.</td>
<td>6.0979</td>
</tr>
<tr>
<td>Muscovite</td>
<td>10</td>
<td>4.</td>
<td>5.2433</td>
</tr>
<tr>
<td>Silica cement</td>
<td>11</td>
<td>5.</td>
<td>6.0589</td>
</tr>
<tr>
<td>Calcite</td>
<td>12</td>
<td>6.</td>
<td>4.5598</td>
</tr>
<tr>
<td>Chert</td>
<td>13</td>
<td>7.</td>
<td>4.6878</td>
</tr>
<tr>
<td>Sericite</td>
<td>14</td>
<td>8.</td>
<td>5.5462</td>
</tr>
<tr>
<td>Pyrite</td>
<td>15</td>
<td>9.</td>
<td>5.1178</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>17</td>
<td>10.</td>
<td>5.0023</td>
</tr>
<tr>
<td>Kaolin</td>
<td>18</td>
<td>11.</td>
<td>5.8120</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>19</td>
<td>12.</td>
<td>5.2877</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>20</td>
<td>13.</td>
<td>5.2653</td>
</tr>
<tr>
<td>Chlorite</td>
<td>21</td>
<td>14.</td>
<td>4.8283</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>22</td>
<td>15.</td>
<td>6.2877</td>
</tr>
<tr>
<td>Zircon</td>
<td>23</td>
<td>16.</td>
<td>5.6153</td>
</tr>
<tr>
<td>Microcline</td>
<td>24</td>
<td>17.</td>
<td>4.7408</td>
</tr>
<tr>
<td>Limonite</td>
<td>25</td>
<td>18.</td>
<td>5.6612</td>
</tr>
<tr>
<td>Magnetite</td>
<td>26</td>
<td>19.</td>
<td>5.1380</td>
</tr>
<tr>
<td>Biotite</td>
<td>27</td>
<td>20.</td>
<td>5.6295</td>
</tr>
<tr>
<td>Rutile</td>
<td>28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0256
Average grain size in Ø 5.3638
Variance (s²) calculated in Ø 0.2391
Color of rock chip W 4
APPENDIX A

Rock Type 11 Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/16
Depth Below Surface (in feet) 135.9
Core Number G-8

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>2</td>
<td>1. 0.0316 4.9839</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>2. 0.0638 3.9703</td>
</tr>
<tr>
<td>Muscovite</td>
<td>11</td>
<td>3. 0.0222 5.4933</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4. 0.0506 4.3047</td>
</tr>
<tr>
<td>Calcite</td>
<td>6</td>
<td>5. 0.0368 4.7642</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6. 0.0360 4.7959</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7. 0.0162 5.9479</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8. 0.0136 6.2002</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9. 0.0222 5.4933</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10. 0.0218 5.5195</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11. 0.0276 5.1688</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12. 0.0424 4.5598</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13. 0.0322 4.9568</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14. 0.0182 5.7799</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15. 0.0240 5.3808</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16. 0.0314 4.9931</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17. 0.0116 6.4297</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18. 0.0708 3.8201</td>
</tr>
<tr>
<td>Ilhotite</td>
<td>-</td>
<td>19. 0.0284 5.1380</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20. 0.0346 4.8531</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total 100

Average grain size in mm 0.0318
Average grain size in Ø 5.1277
Variance (s²) calculated in Ø 0.4666
Color of rock chip N 4
APPENDIX A

Rock Type 11
Mixed Disturbed Structure and
Graded Bedding Shale

Thin Section Number 11/17
Depth Below Surface (in feet) 137.2
Core Number G-8

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>39</td>
<td>0.0166</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>3</td>
<td>0.0168</td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td>0.194</td>
</tr>
<tr>
<td>Silica cement</td>
<td></td>
<td>0.0296</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>0.0414</td>
</tr>
<tr>
<td>Chert</td>
<td></td>
<td>0.0352</td>
</tr>
<tr>
<td>Sericite</td>
<td></td>
<td>0.0184</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>0.0216</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>0.0130</td>
</tr>
<tr>
<td>Kaolin</td>
<td></td>
<td>0.0158</td>
</tr>
<tr>
<td>Leucoxene</td>
<td></td>
<td>0.0108</td>
</tr>
<tr>
<td>Orthoclase</td>
<td></td>
<td>0.0224</td>
</tr>
<tr>
<td>Chlorite</td>
<td></td>
<td>0.0188</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td></td>
<td>0.0144</td>
</tr>
<tr>
<td>Zircon</td>
<td></td>
<td>0.0268</td>
</tr>
<tr>
<td>Microcline</td>
<td></td>
<td>0.0218</td>
</tr>
<tr>
<td>Limonite</td>
<td></td>
<td>0.0130</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>0.0146</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>0.0238</td>
</tr>
<tr>
<td>Rutile</td>
<td></td>
<td>0.0626</td>
</tr>
<tr>
<td>Garnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0228
Average grain size in $\phi$ 5.5951
Variance ($s^2$) calculated in $\phi$ 0.3849
Color of rock chip N 5
APPENDIX A

Rock Type 11 Mixed Disturbed Structure and Graded Bedding Shale

Thin Section Number 11/18

Depth Below Surface (in feet) 141.1

Core Number G-8

Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>1</td>
<td>1.0184</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>7</td>
<td>2.0208</td>
</tr>
<tr>
<td>Muscovite</td>
<td>3</td>
<td>3.0136</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>4.0164</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
<td>5.0236</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>6.0194</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>7.0230</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>8.0252</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
<td>9.0288</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>10.0224</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>11.0208</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>12.0236</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>13.0144</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>14.0362</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>15.0192</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>16.0344</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>17.0154</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>18.0240</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>19.0244</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>20.0102</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in mm 0.0218

Average grain size in $\phi$ 5.5827

Variance ($s^2$) calculated in $\phi$ 0.1989

Color of rock chip $N3$
APPENDIX B

Mineral Composition and Grain Size Data of the Total Cored Section and of Each Rock Type
APPENDIX B

Total of All 11 Rock Types

Total footage of all types 297 feet

Data from thin sections 02/02, 06/02 and 08/02 have been removed so that the three rock types from which they were taken will not receive more weight than their true percentage demands (see text), therefore, the total number of thin sections used in this table is 100, not 103.

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>46.38</td>
<td>Percentage of grains with apparent long axes larger than Ø:</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7.91</td>
<td>Ø (%)</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>22.47</td>
<td>7.50</td>
</tr>
<tr>
<td>Illite</td>
<td>6.70</td>
<td>7.00</td>
</tr>
<tr>
<td>Siderite</td>
<td>4.61</td>
<td>6.50</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2.79</td>
<td>6.00</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2.78</td>
<td>5.50</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1.62</td>
<td>5.00</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.32</td>
<td>4.50</td>
</tr>
<tr>
<td>Chert</td>
<td>0.72</td>
<td>4.00</td>
</tr>
<tr>
<td>Sericite</td>
<td>0.62</td>
<td>3.50</td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.55</td>
<td>3.00</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.45</td>
<td>2.50</td>
</tr>
<tr>
<td>Kaolin</td>
<td>0.20</td>
<td>2.00</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>0.17</td>
<td>1.50</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>0.16</td>
<td>1.00</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.12</td>
<td>0.50</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>0.12</td>
<td>0.00</td>
</tr>
<tr>
<td>Zircon</td>
<td>0.10</td>
<td>-0.50</td>
</tr>
<tr>
<td>Microcline</td>
<td>0.08</td>
<td>-1.00</td>
</tr>
<tr>
<td>Limonite</td>
<td>0.05</td>
<td>-1.50</td>
</tr>
<tr>
<td>Magnetite</td>
<td>0.03</td>
<td>-2.00</td>
</tr>
<tr>
<td>Biotite</td>
<td>0.03</td>
<td>-2.50</td>
</tr>
<tr>
<td>Rutile</td>
<td>0.01</td>
<td>Total 100.00</td>
</tr>
<tr>
<td>Garnet</td>
<td>0.01</td>
<td>Total 100.00</td>
</tr>
</tbody>
</table>

The following figures have been corrected as described above.

- **Average grain size in Ø**: 3.63
- **Average grain size in mm**: 0.195
- **Variance (s²) calculated in Ø**: 3.086
- **Range of grain size in Ø**: 7.29 to -2.67
- **Range of grain size in mm**: 0.006 to 6.350
- **Range of s² of thin sections**: 0.112 to 3.231
- **Range of average grain size in Ø of thin sections**: 5.84 to -0.98
## APPENDIX B

### Massie Brown Sandstone vs. Rock Type 01

<table>
<thead>
<tr>
<th>Total footage in cores</th>
<th>72.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of total core footage</td>
<td>24.3</td>
</tr>
<tr>
<td>Number of thin sections</td>
<td>24</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74.71</td>
<td>Percentage of grains with apparent long axes larger than $\phi$:</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7.29</td>
<td>$\phi$</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td>4.75</td>
</tr>
<tr>
<td>Illite</td>
<td>2.00</td>
<td>4.50</td>
</tr>
<tr>
<td>Siderite</td>
<td>7.13</td>
<td>4.25</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>0.13</td>
<td>4.00</td>
</tr>
<tr>
<td>Muscovite</td>
<td>0.75</td>
<td>3.75</td>
</tr>
<tr>
<td>Silica cement</td>
<td>3.33</td>
<td>3.50</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.79</td>
<td>3.25</td>
</tr>
<tr>
<td>Chert</td>
<td>0.42</td>
<td>3.00</td>
</tr>
<tr>
<td>Sericite</td>
<td>0.04</td>
<td>2.75</td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.67</td>
<td>2.50</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.38</td>
<td>2.25</td>
</tr>
<tr>
<td>Kaolin</td>
<td>0.04</td>
<td>2.00</td>
</tr>
<tr>
<td>Leucoxane</td>
<td>0.21</td>
<td>1.75</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>0.12</td>
<td>1.50</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.33</td>
<td>1.25</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Zircon</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Micaclase</td>
<td>0.08</td>
<td>0.50</td>
</tr>
<tr>
<td>Magnetite</td>
<td>0.04</td>
<td>0.25</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.00</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td>-0.25</td>
</tr>
<tr>
<td>Garnet</td>
<td>0.04</td>
<td>-0.50</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>Total 100.00</td>
</tr>
</tbody>
</table>

### Average grain size in $\phi$ 2.27
### Average grain size in $\text{mm}$ 0.246
### Variance (s^2) calculated in $\phi$ 0.720

$s^2$ is not homogeneous (95% confidence level)

### Range of grain size in $\phi$ 4.87 to -0.76
### Range of grain size in $\text{mm}$ 0.034 to 1.694
### Range of $s^2$ of thin sections 0.203 to 1.851
### Range of average grain size in $\phi$ of thin sections 2.74 to 1.87
APPENDIX B

**Bedded Brown Sandstone**

<table>
<thead>
<tr>
<th>Total footage in cores</th>
<th>2.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of total core footage</td>
<td>0.7</td>
</tr>
<tr>
<td>Number of thin sections</td>
<td>2</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>74.00</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5.50</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>2.50</td>
</tr>
<tr>
<td>Illite</td>
<td>6.00</td>
</tr>
<tr>
<td>Siderite</td>
<td>4.00</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>1.00</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2.50</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2.25</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.75</td>
</tr>
<tr>
<td>Chert</td>
<td>2.00</td>
</tr>
<tr>
<td>Sericite</td>
<td>1.50</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1.50</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.50</td>
</tr>
<tr>
<td>Kaolin</td>
<td>3.75</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>3.50</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>3.25</td>
</tr>
<tr>
<td>Chlorite</td>
<td>3.00</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>2.75</td>
</tr>
<tr>
<td>Zircon</td>
<td>2.50</td>
</tr>
<tr>
<td>Microcline</td>
<td>2.25</td>
</tr>
<tr>
<td>Limonite</td>
<td>2.00</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1.75</td>
</tr>
<tr>
<td>Biotite</td>
<td>1.50</td>
</tr>
<tr>
<td>Rutile</td>
<td>Total</td>
</tr>
<tr>
<td>Garnet</td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Grain Size

<table>
<thead>
<tr>
<th>Percentage of grains with apparent long axes larger than Ø:</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>5.0000</td>
</tr>
<tr>
<td>3.75</td>
<td>10.0000</td>
</tr>
<tr>
<td>3.50</td>
<td>5.0000</td>
</tr>
<tr>
<td>3.25</td>
<td>15.0000</td>
</tr>
<tr>
<td>3.00</td>
<td>10.0000</td>
</tr>
<tr>
<td>2.75</td>
<td>12.5000</td>
</tr>
<tr>
<td>2.50</td>
<td>15.0000</td>
</tr>
<tr>
<td>2.25</td>
<td>7.5000</td>
</tr>
<tr>
<td>2.00</td>
<td>Total</td>
</tr>
<tr>
<td>1.75</td>
<td>100.0000</td>
</tr>
</tbody>
</table>

**Average grain size in Ø**

- 2.44

**Average grain size in mm**

- 0.203

**Variance (s²) calculated in Ø**

- 0.418

**s² is homogeneous (95% confidence level)**

**Range of grain size in Ø**

- 3.57 to 1.38

**Range of grain size in mm**

- 0.084 to 0.383

**Range of s² of thin sections**

- 0.343 to 0.500

**Range of average grain size in Ø of thin sections**

- 2.52 to 2.35
APPENDIX B

**Pebbly Brown Sandstone**

<table>
<thead>
<tr>
<th>Composition</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mineral</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>Dusty quartz</td>
<td>87.00</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>3.50</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>0.50</td>
</tr>
<tr>
<td>Siderite</td>
<td>4.00</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td>0.50</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2.75</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>0.50</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.50</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>0.25</td>
</tr>
<tr>
<td>Leucocline</td>
<td>-</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>0.25</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>0.25</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

Average grain size in Ø | 1.38
Average grain size in mm | 0.537
Variance (σ²) calculated in Ø | 1.246
σ² is homogeneous (95% confidence level)
Range of grain size in Ø | 3.55 to -1.55
Range of grain size in mm | 0.086 to 2.925
Range of σ² of thin sections | 0.826 to 1.291
Range of average grain size in Ø of thin sections | 2.15 to 0.73
### APPENDIX B

<table>
<thead>
<tr>
<th>Massive Gray Sandstone</th>
<th>Rock Type O4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total footage in cores</td>
<td>51.4</td>
</tr>
<tr>
<td>Per cent of total core footage</td>
<td>17.3</td>
</tr>
<tr>
<td>Number of thin sections</td>
<td>17</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Composition</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>75.18</td>
<td>Percentage of grains with apparent long axes larger than $\phi$:</td>
<td></td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illite</td>
<td>10.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siderite</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscovite</td>
<td>0.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica cement</td>
<td>1.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td>0.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chert</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sericite</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kaolin</td>
<td>0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucoxane</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zircon</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microcline</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limonite</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotite</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Grain size in $\phi$    | 2.61 |
| Average grain size in $\phi$ | 0.202 |
| Variance ($s^2$) calculated in $\phi$ | 0.706 |

$s^2$ is not homogeneous (95% confidence level)

| Range of grain size in $\phi$ | 4.67 to -2.03 |
| Range of grain size in mm     | 0.039 to 4.094 |
| Range of $s^2$ of thin sections | 0.152 to 1.665 |
| Range of average grain size in $\phi$ of thin sections | 3.10 to 1.92 |
### Bedded Gray Sandstone

<table>
<thead>
<tr>
<th>Composition</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>52.40</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>5.90</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>17.00</td>
</tr>
<tr>
<td>Siderite</td>
<td>2.10</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>2.70</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4.10</td>
</tr>
<tr>
<td>Silica cement</td>
<td>2.70</td>
</tr>
<tr>
<td>Calcite</td>
<td>7.40</td>
</tr>
<tr>
<td>Chert</td>
<td>0.80</td>
</tr>
<tr>
<td>Sericite</td>
<td>2.40</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>0.80</td>
</tr>
<tr>
<td>Kaolin</td>
<td>0.40</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>0.40</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>0.10</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.20</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>0.10</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>0.30</td>
</tr>
<tr>
<td>Magnetite</td>
<td>0.10</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>0.10</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

- **Average grain size in Ø:** 3.75
- **Average grain size in mm:** 0.090
- **Variance (s²) calculated in Ø:** 0.753
- **s² is homogeneous (95% confidence level):**
- **Range of grain size in Ø:** 5.78 to 1.00
- **Range of grain size in mm:** 0.018 to 0.500
- **Range of s² of thin sections:** 0.112 to 0.458
- **Range of average grain size in Ø of thin sections:** 4.83 to 2.25
APPENDIX B

Pebbly Gray Sandstone  

<table>
<thead>
<tr>
<th>Composition</th>
<th>%</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>58.00</td>
<td>Percentage of grains with apparent long axes larger than Ø:</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7.50</td>
<td>Ø</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
<td>4.50</td>
</tr>
<tr>
<td>Illite</td>
<td>3.50</td>
<td>2.5000</td>
</tr>
<tr>
<td>Siderite</td>
<td>26.00</td>
<td></td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
<td>4.25</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2.50</td>
<td>4.00</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
<td>2.5000</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.50</td>
<td>3.75</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
<td>7.5000</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
<td>3.50</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
<td>5.0000</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1.00</td>
<td>2.75</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
<td>12.5000</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>-</td>
<td>2.00</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
<td>10.0000</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
<td>1.75</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
<td>2.5000</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
<td>1.50</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
<td>5.0000</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
<td>1.00</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
<td>2.5000</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
<td>0.75</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
<td>Total 100.0000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in Ø: 2.53
Average grain size in mm: 0.205
Variance ($s^2$) calculated in Ø: 0.745

$s^2$ is homogeneous (95% confidence level)

Range of grain size in Ø: 4.43 to 0.69
Range of grain size in mm: 0.046 to 0.619
Range of $s^2$ of thin sections: 0.670 to 0.859
Range of average grain size in Ø of thin sections: 2.55 to 2.52
### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>95.50</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>1.00</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Illite</td>
<td>.50</td>
</tr>
<tr>
<td>Siderite</td>
<td>-</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>-</td>
</tr>
<tr>
<td>Micaeous</td>
<td>-</td>
</tr>
<tr>
<td>Silica cement</td>
<td>1.00</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>1.00</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolin</td>
<td>1.00</td>
</tr>
<tr>
<td>Leucosome</td>
<td>-</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
</tr>
<tr>
<td>Micaeous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnete</td>
<td>-</td>
</tr>
<tr>
<td>Rutil</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Grain Size

<table>
<thead>
<tr>
<th>Percentage of grains with apparent long axes larger than $\bar{\phi}$:</th>
<th>$\bar{\phi}$</th>
<th>$%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>2.75</td>
<td>5.0000</td>
</tr>
<tr>
<td>2.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.25</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>2.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.75</td>
<td>5.0000</td>
<td></td>
</tr>
<tr>
<td>1.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.25</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>5.0000</td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>5.0000</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>7.5000</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-0.25</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>-0.50</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>-0.75</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>-1.00</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>-1.25</td>
<td>10.0000</td>
<td></td>
</tr>
<tr>
<td>-1.50</td>
<td>2.5000</td>
<td></td>
</tr>
<tr>
<td>-1.75</td>
<td>17.5000</td>
<td></td>
</tr>
<tr>
<td>-2.00</td>
<td>7.5000</td>
<td></td>
</tr>
<tr>
<td>-2.25</td>
<td>12.5000</td>
<td></td>
</tr>
<tr>
<td>-2.50</td>
<td>7.5000</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0000</td>
<td></td>
</tr>
</tbody>
</table>

Average grain size in $\bar{\phi}$: -0.85
Average grain size in $\bar{\phi}$: 2.766
Variance ($s^2$) calculated in $\bar{\phi}$: 2.535
$s^2$ is homogeneous (95% confidence level)
Range of grain size in $\bar{\phi}$: 2.67 to -2.67
Range of grain size in $\bar{\phi}$: 0.156 to 6.350
Range of $s^2$ of thin sections: 1.939 to 3.321
Range of average grain size of $\bar{\phi}$ of thin sections: -0.73 to -0.98
APPENDIX B

Massive Shale  Rock Type 06

| Total footage in cores | 2.6 |
| Per cent of total core footage | 0.9 |
| Number of thin sections | 2 |

<table>
<thead>
<tr>
<th>Composition</th>
<th>Grain Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
<td>%</td>
</tr>
<tr>
<td>Dusty quartz</td>
<td>5.50</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>7.50</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>75.00</td>
</tr>
<tr>
<td>Illite</td>
<td>1.50</td>
</tr>
<tr>
<td>Siderite</td>
<td>0.50</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6.50</td>
</tr>
<tr>
<td>Muscovite</td>
<td>2.50</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
</tr>
<tr>
<td>Calcite</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>0.50</td>
</tr>
<tr>
<td>Sericite</td>
<td>0.50</td>
</tr>
<tr>
<td>Pyrite</td>
<td>-</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
</tr>
<tr>
<td>Leucocene</td>
<td>-</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>-</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
</tbody>
</table>

Average grain size in Ø: 5.11
Average grain size in mm: 0.032
Variance (s²) calculated in Ø: 0.399
s² is homogeneous (95% confidence level)
Range of grain size in Ø: 6.29 to 4.06
Range of grain size in mm: 0.013 to 0.060
Range of s² of thin sections: 0.318 to 0.434
Range of average grain size in Ø of thin sections: 5.29 to 4.93
### APPENDIX B

**Disturbed Structure Shale**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>15.55</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>8.55</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>35.00</td>
</tr>
<tr>
<td>Illite</td>
<td>18.46</td>
</tr>
<tr>
<td>Siderite</td>
<td>6.27</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5.36</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4.36</td>
</tr>
<tr>
<td>Silica cement</td>
<td>0.46</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.27</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
</tr>
<tr>
<td>Sericite</td>
<td>1.18</td>
</tr>
<tr>
<td>Pyrite</td>
<td>3.18</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>0.27</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.09</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
</tbody>
</table>

**Rock Type 09**

<table>
<thead>
<tr>
<th>Grain Size</th>
<th>Percentage of grains with apparent long axes larger than φ:</th>
</tr>
</thead>
<tbody>
<tr>
<td>φ</td>
<td>%</td>
</tr>
<tr>
<td>7.50</td>
<td>.4546</td>
</tr>
<tr>
<td>7.25</td>
<td>1.3636</td>
</tr>
<tr>
<td>7.00</td>
<td>.9091</td>
</tr>
<tr>
<td>6.75</td>
<td>3.1818</td>
</tr>
<tr>
<td>6.50</td>
<td>4.0909</td>
</tr>
<tr>
<td>6.25</td>
<td>4.5454</td>
</tr>
<tr>
<td>6.00</td>
<td>3.6363</td>
</tr>
<tr>
<td>5.75</td>
<td>13.6364</td>
</tr>
<tr>
<td>5.50</td>
<td>6.8182</td>
</tr>
<tr>
<td>5.25</td>
<td>12.2727</td>
</tr>
<tr>
<td>5.00</td>
<td>8.6364</td>
</tr>
<tr>
<td>4.75</td>
<td>11.8182</td>
</tr>
<tr>
<td>4.50</td>
<td>9.5454</td>
</tr>
<tr>
<td>4.25</td>
<td>10.9091</td>
</tr>
<tr>
<td>4.00</td>
<td>5.4545</td>
</tr>
<tr>
<td>3.75</td>
<td>1.8182</td>
</tr>
<tr>
<td>3.50</td>
<td>.4546</td>
</tr>
<tr>
<td>3.25</td>
<td>.4546</td>
</tr>
<tr>
<td>Total</td>
<td>100.0000</td>
</tr>
</tbody>
</table>

**Average grain size in φ**

<table>
<thead>
<tr>
<th>Average grain size</th>
<th>5.06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average grain size in mm</td>
<td>0.035</td>
</tr>
<tr>
<td>Variance (s²) calculated in φ</td>
<td>0.694</td>
</tr>
<tr>
<td>s² is homogeneous (95% confidence level)</td>
<td></td>
</tr>
<tr>
<td>Range of grain size in φ</td>
<td>7.29 to 3.07</td>
</tr>
<tr>
<td>Range of grain size in mm</td>
<td>0.006 to 0.119</td>
</tr>
<tr>
<td>Range of s² of thin sections</td>
<td>0.240 to 1.123</td>
</tr>
<tr>
<td>Range of average grain size in φ of thin sections</td>
<td>5.60 to 4.43</td>
</tr>
</tbody>
</table>
### APPENDIX B

#### Graded Bedding Shale  
#### Rock Type 10

<table>
<thead>
<tr>
<th>Total footage in cores</th>
<th>33.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent of total core footage</td>
<td>11.4</td>
</tr>
<tr>
<td>Number of thin sections</td>
<td>11</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartz</td>
<td>5.36</td>
</tr>
<tr>
<td>Clear quartz</td>
<td>12.73</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>66.82</td>
</tr>
<tr>
<td>Illite</td>
<td>3.00</td>
</tr>
<tr>
<td>Siderite</td>
<td>2.18</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>5.46</td>
</tr>
<tr>
<td>Muscovite</td>
<td>4.00</td>
</tr>
<tr>
<td>Silica cement</td>
<td>-</td>
</tr>
<tr>
<td>Calcite</td>
<td>0.18</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.09</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolin</td>
<td>-</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>0.09</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.09</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>-</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

#### Grain Size

<table>
<thead>
<tr>
<th>Percentage of grains with apparent long axes larger than Ø</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td>7.25</td>
</tr>
<tr>
<td></td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>6.75</td>
</tr>
<tr>
<td></td>
<td>6.50</td>
</tr>
<tr>
<td></td>
<td>6.25</td>
</tr>
<tr>
<td></td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>4.75</td>
</tr>
<tr>
<td></td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>4.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Average grain size in Ø**  5.47

**Average grain size in mm**  0.024

**Variance (σ²) calculated in Ø**  0.347

σ² is homogeneous (95% confidence level)

**Range of grain size in Ø**  7.29 to 4.09

**Range of grain size in mm**  0.006 to 0.059

**Range of σ² of thin sections**  0.149 to 0.393

**Range of average grain size in Ø of thin sections**  4.84 to 5.13
### APPENDIX B

#### Mixed Disturbed Structure and Graded Bedding Shale

<table>
<thead>
<tr>
<th>Rock Type LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total footage in cores</td>
</tr>
<tr>
<td>Per cent of total core footage</td>
</tr>
<tr>
<td>Number of thin sections</td>
</tr>
</tbody>
</table>

#### Composition

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty quartes</td>
<td>7.61</td>
</tr>
<tr>
<td>Clear quartes</td>
<td>10.61</td>
</tr>
<tr>
<td>Illite-Siderite</td>
<td>58.44</td>
</tr>
<tr>
<td>Illite</td>
<td>1.56</td>
</tr>
<tr>
<td>Siderite</td>
<td>6.50</td>
</tr>
<tr>
<td>Carbonaceous matter</td>
<td>6.72</td>
</tr>
<tr>
<td>Muscovite</td>
<td>6.00</td>
</tr>
<tr>
<td>Silica cement</td>
<td>0.06</td>
</tr>
<tr>
<td>Calcite</td>
<td>1.39</td>
</tr>
<tr>
<td>Chert</td>
<td>-</td>
</tr>
<tr>
<td>Sericite</td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.83</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>-</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>-</td>
</tr>
<tr>
<td>Leucoxune</td>
<td>0.11</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>-</td>
</tr>
<tr>
<td>Chlorite</td>
<td>0.11</td>
</tr>
<tr>
<td>Micaceous rock frag.</td>
<td>-</td>
</tr>
<tr>
<td>Zircon</td>
<td>0.06</td>
</tr>
<tr>
<td>Microcline</td>
<td>-</td>
</tr>
<tr>
<td>Limonite</td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td>-</td>
</tr>
<tr>
<td>Rutile</td>
<td>-</td>
</tr>
<tr>
<td>Garnet</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

#### Grain Size

| Percentage of grains with apparent long axes larger than Ø: |
|----------------|---------|
| Ø             | %       |
| 7.25          | .2778   |
| 7.00          | .2778   |
| 6.75          | 2.2222  |
| 6.50          | 3.3333  |
| 6.25          | 10.0000 |
| 6.00          | 10.8333 |
| 5.75          | 18.0555 |
| 5.50          | 17.7778 |
| 5.25          | 12.5000 |
| 5.00          | 7.7778  |
| 4.75          | 8.0556  |
| 4.50          | 4.1111  |
| 4.25          | 1.1111  |
| 4.00          | 1.9444  |
| 3.75          | 5.5556  |
| 3.50          | -       |
| 3.25          | .2778   |
| 3.00          | .2778   |
| 2.75          | -       |
| 2.50          | -       |
| 2.25          | -       |
| 2.00          | .2778   |
| **Total**     | **100.0000** |

- Average grain size in Ø: 5.37
- Average grain size in mm: 0.027
- Variance (s²) calculated in Ø: 0.428
- s² is not homogeneous (95% confidence level)
- Range of grain size in Ø: 7.08 to 1.98
- Range of grain size in mm: 0.007 to 0.254
- Range of s² of thin sections: 0.168 to 1.520
- Range of average grain size in Ø of thin sections: 5.60 to 4.95
APPENDIX C

Stratigraphic Distribution of the Rock Types
APPENDIX C

The rock types are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Identification Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive Brown Sandstone</td>
<td>01</td>
</tr>
<tr>
<td>Bedded Brown Sandstone</td>
<td>02</td>
</tr>
<tr>
<td>Pebbly Brown Sandstone</td>
<td>03</td>
</tr>
<tr>
<td>Massive Gray Sandstone</td>
<td>04</td>
</tr>
<tr>
<td>Bedded Gray Sandstone</td>
<td>05</td>
</tr>
<tr>
<td>Pebbly Gray Sandstone</td>
<td>06</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>07</td>
</tr>
<tr>
<td>Massive Shale</td>
<td>08</td>
</tr>
<tr>
<td>Disturbed Structure Shale</td>
<td>09</td>
</tr>
<tr>
<td>Graded Bedding Shale</td>
<td>10</td>
</tr>
<tr>
<td>Mixed Disturbed Structure and Graded Bedding Shale</td>
<td>11</td>
</tr>
</tbody>
</table>

The rock types are distributed through the stratigraphic section studied as follows:

<table>
<thead>
<tr>
<th>Core G-9</th>
<th>Rock Type Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth in feet</td>
<td></td>
</tr>
<tr>
<td>20.3 - 57.4</td>
<td>01</td>
</tr>
<tr>
<td>57.4 - 58.8</td>
<td>03</td>
</tr>
<tr>
<td>58.8 - 59.8</td>
<td>01</td>
</tr>
<tr>
<td>59.8 - 61.9</td>
<td>02</td>
</tr>
<tr>
<td>61.9 - 62.8</td>
<td>01</td>
</tr>
<tr>
<td>62.8 - 63.9</td>
<td>03</td>
</tr>
<tr>
<td>63.9 - 66.5</td>
<td>01</td>
</tr>
<tr>
<td>Core G-9 (Continued)</td>
<td>Rock Type Number</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>66.5 - 68.0</td>
<td>05</td>
</tr>
<tr>
<td>68.0 - 81.2</td>
<td>01</td>
</tr>
<tr>
<td>81.2 - 82.0</td>
<td>03</td>
</tr>
<tr>
<td>82.0 - 85.2</td>
<td>01</td>
</tr>
<tr>
<td>85.2 - 86.8</td>
<td>06</td>
</tr>
<tr>
<td>86.8 - 89.6</td>
<td>01</td>
</tr>
<tr>
<td>89.6 - 90.2</td>
<td>07</td>
</tr>
<tr>
<td>90.2 - 94.9</td>
<td>03</td>
</tr>
<tr>
<td>94.9 - 99.7</td>
<td>01</td>
</tr>
<tr>
<td>99.7 - 100.1</td>
<td>03</td>
</tr>
<tr>
<td>100.1 - 103.2</td>
<td>01</td>
</tr>
<tr>
<td>103.2 - 104.0</td>
<td>03</td>
</tr>
<tr>
<td>104.0 - 107.5</td>
<td>01</td>
</tr>
<tr>
<td>107.5 - 110.3</td>
<td>03</td>
</tr>
<tr>
<td>110.3 - 115.8</td>
<td>07</td>
</tr>
<tr>
<td>115.8 - 135.7</td>
<td>09</td>
</tr>
<tr>
<td>135.7 - 140.7</td>
<td>11</td>
</tr>
<tr>
<td>140.7 - 147.0</td>
<td>09</td>
</tr>
<tr>
<td>147.0 - 151.1</td>
<td>05</td>
</tr>
<tr>
<td>151.1 - 154.2</td>
<td>11</td>
</tr>
<tr>
<td>154.2 - 159.8</td>
<td>05</td>
</tr>
<tr>
<td>159.8 - 160.4</td>
<td>08</td>
</tr>
<tr>
<td>160.4 - 161.9</td>
<td>05</td>
</tr>
<tr>
<td>161.9 - 162.5</td>
<td>08</td>
</tr>
<tr>
<td>Core G-9</td>
<td>Rock Type Number</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>162.5 - 162.8</td>
<td>05</td>
</tr>
<tr>
<td>162.8 - 163.2</td>
<td>08</td>
</tr>
<tr>
<td>163.2 - 165.8</td>
<td>05</td>
</tr>
<tr>
<td>165.8 - 169.7</td>
<td>04</td>
</tr>
<tr>
<td>169.7 - 170.0</td>
<td>09</td>
</tr>
<tr>
<td>170.0 - 171.1</td>
<td>04</td>
</tr>
<tr>
<td>171.1 - 173.3</td>
<td>11</td>
</tr>
<tr>
<td>173.3 - 174.1</td>
<td>10</td>
</tr>
<tr>
<td>174.1 - 174.9</td>
<td>09</td>
</tr>
<tr>
<td>174.9 - 177.8</td>
<td>10</td>
</tr>
<tr>
<td>177.8 - 178.1</td>
<td>05</td>
</tr>
<tr>
<td>178.1 - 179.1</td>
<td>11</td>
</tr>
<tr>
<td>179.1 - 180.3</td>
<td>10</td>
</tr>
<tr>
<td>180.3 - 184.1</td>
<td>09</td>
</tr>
<tr>
<td>184.1 - 188.3</td>
<td>10</td>
</tr>
<tr>
<td>188.3 - 195.3</td>
<td>11</td>
</tr>
<tr>
<td>195.3 - 195.7</td>
<td>05</td>
</tr>
<tr>
<td>195.7 - 196.9</td>
<td>11</td>
</tr>
<tr>
<td>196.9 - 197.2</td>
<td>05</td>
</tr>
<tr>
<td>197.2 - 199.0</td>
<td>11</td>
</tr>
<tr>
<td>199.0 - 199.6</td>
<td>05</td>
</tr>
<tr>
<td>199.6 - 200.1</td>
<td>11</td>
</tr>
<tr>
<td>200.1 - 201.7</td>
<td>05</td>
</tr>
<tr>
<td>201.7 - 204.2</td>
<td>10</td>
</tr>
</tbody>
</table>
Core G-9 (Continued) | Rock Type Number
--- | ---
204.2 - 205.3 | 09
205.3 - 206.6 | 10
206.6 - 207.0 | 05
207.0 - 211.0 | 10
211.0 - 211.4 | 05
211.4 - 212.3 | 10
212.3 - 212.5 | 05
212.5 - 220.1 | 10
220.1 - 220.5 | 05
220.5 - 225.1 | 10
225.1 - 226.3 | 05
226.3 - 227.6 | 11
227.6 - 228.2 | 05
228.2 - 230.4 | 11
230.4 - 230.9 | 05
230.9 - 232.3 | 10
232.3 - 236.4 | 11
236.4 - 238.4 | 10
238.4 - 258.0 | 04

Core G-9 was correlated at this point with core G-8.

Core G-8 follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>109.6 - 118.5</td>
<td>11</td>
</tr>
<tr>
<td>118.5 - 121.5</td>
<td>04</td>
</tr>
<tr>
<td>Core G-8</td>
<td>Rock Type Number</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>(Continued)</td>
<td></td>
</tr>
<tr>
<td>121.5 - 121.9</td>
<td>09</td>
</tr>
<tr>
<td>121.9 - 125.4</td>
<td>05</td>
</tr>
<tr>
<td>125.4 - 127.0</td>
<td>11</td>
</tr>
<tr>
<td>127.0 - 128.0</td>
<td>05</td>
</tr>
<tr>
<td>128.0 - 132.4</td>
<td>11</td>
</tr>
<tr>
<td>132.4 - 133.4</td>
<td>08</td>
</tr>
<tr>
<td>133.4 - 143.2</td>
<td>11</td>
</tr>
<tr>
<td>143.2 - 144.7</td>
<td>05</td>
</tr>
<tr>
<td>144.7 - 155.5</td>
<td>04</td>
</tr>
<tr>
<td>155.5 - 155.9</td>
<td>10</td>
</tr>
<tr>
<td>155.9 - 168.9</td>
<td>04</td>
</tr>
</tbody>
</table>

Bottom of stratigraphic section studied.
APPENDIX D

Recovery, Concentration, and Identification of Spores
APPENDIX D

Fifty-five samples were taken from the shales and were treated for the removal and concentration of spores as follows:

1. Sample was pulverized.
2. Treated for two hours in a solution consisting of equal parts of concentrated nitric acid and a saturated solution of potassium chlorate.
3. Seven minutes in ultrasonic cleaner.
4. Mixed with water to make one liter, settled in a one liter cylinder for 18 hours; liquid siphoned off, precipitate retained.
5. Centrifuged two minutes. Precipitate retained.
6. Treated in \( \text{H}_2\text{O}_2 \) for 18 hours.
7. Centrifuged two minutes; precipitate retained.
8. Treated in concentrated HF for 24 hours.
9. Centrifuged two minutes; precipitate retained.
10. Boiled 30 seconds in concentrated HCl; centrifuged and precipitate retained.
11. Washed and centrifuged four times (or until HCl was completely removed); precipitate retained.
12. Put in saturated ZnCl solution, stirred and centrifuged; suspension retained.
13. Suspension put in clean tube, centrifuged again; suspension retained.
14. Put in 50 ml beaker with 5 ml concentrated HCl and water added to make 50 ml; centrifuged and precipitate retained.

15. Washed and centrifuged four times (or until HCl was completely removed); precipitate retained.

16. Safranin dye added to precipitate and left to stand 24 hours.

17. Washed and centrifuged four times to remove dye; precipitate retained.

18. Glycerine added to precipitate and transferred to storage vial.

19. Slides for microscopic study were made from the above.

Photomicrographs of the spores found in the samples were sent to Dr. Gerhard O. W. Kemp for confirmation or correction of identification. They are as follows:

1. Apiculatiesites sp.

2. Laevigato-sporites sp. cf. Microreticulatisporites sp.

3. Lycospora sp.


6. Microreticulatisporites sp.
VITA

C. Edward Howard was born in Roseboro, North Carolina, on May 31, 1929. He attended elementary school in Clinton, North Carolina, and graduated from Clinton High School in 1947. He received a Bachelor of Science degree in Geology from Duke University in 1953 and a Master of Science degree in Geological Engineering from North Carolina State College in 1955. In June, 1955, he was employed by the Tungsten Mining Corporation of Henderson, North Carolina. He entered the Graduate School at Louisiana State University in February, 1959, and is now a candidate for the Ph.D. degree in Geology.

He is married to the former Evelyn Kline Baker of Henderson, North Carolina.
EXAMINATION AND THESIS REPORT

Candidate: C. Edward Howard

Major Field: Geology

Title of Thesis: Petrography of the Jackfork Sandstone at De Gray Dam, Clark County, Arkansas.

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

May 11, 1963