A SEDIMENTOLOGICAL STUDY OF THE CAP ENRAGÉ CONGLOMERATE, QUÉBEC

TRANSPORT OF CONGLOMERATE INTO DEEP WATER: A STUDY OF THE CAMBRO-ORDOVICIAN CAP ENRAGÉ CONGLOMERATE AT ST. SIMON DE RIMOUSKI, QUÉBEC

By

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SCOPE AND CONTENTS: The Cambro-Ordovician sequence at St. Simon, Québec, was divided informally into ten horizons by Mathey (1970). The most prominent lithologies within the horizons are pelites, feldspathic sandstones and petromict conglomerates. One horizon 50 metres thick of feldspathic sandstones and conglomerates, described in this study, consists of three large fining upward sequences. The fining upward sequences are defined by the occurrence of five facies. These facies are: poorly sorted coarse conglomerates, well sorted coarse conglomerates, medium conglomerates with scattered pebbles and boulders, fine conglomerate with scattered pebbles and boulders and coarse sandstones. The base of each sequence is characterized by the occurrence of coarse conglomerates; the top is characterized by the occurrence of fine conglomerates and coarse sandstones. Rarely do the coarse conglomerates grade into thick developments of medium and fine conglomerates. The fine conglomerates grade in places into coarse sandstones, although generally the coarse sandstones

have sharp bases. The conglomerates display sharp bases, normal and inverse grading, grain imbrication and orientation. The long axes of the grains, which define the orientation are parallel to, and not transverse to the flow direction suggested by the imbrication. To produce these features it is suggested that turbulence and dispersive pressures were operative within the flow. If the pebbles had moved as bed load material, they would have come to rest with their long axes transverse and not parallel to the flow direction suggested by the imbrication. The term "fluxoturbidite" (Dzulynski et al., 1959) has been applied to some coarse grained deposits in geosynclinal sequences. The characteristic features of "fluxoturbidites" are their unusually coarse grain size, thick irregular bedding with associated slump structures and poorly developed grading. The differences between the conglomerates described in this study and the typical "fluxoturbidite" preclude the use of this term to describe the deposits described by the author. It is suggested that the conglomerates were deposited upon a submarine fan complex by currents which flowed parallel to the present tectonic axes.

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CHAPTER 1

INTRODUCTION

Problems of Conglomerates

Conglomerates are common in the Cambro-Ordovician sequences which crop out from Vermont to Newfoundland. Conglomerates have also been reported and well described from many orogenic belts, particularly in Poland (Unrug, 1963), S. America (Scott, 1966) and Wales (Kelling and Wollards, 1969). In the Appalachian literature, many authors have mentioned the occurrence of conglomerates but few have provided detailed descriptions of the conglomerates with palaeocurrent directions.

Within the past twenty years there has been an advance in the level of understanding of deep water clastic sedimentation. Many geologists have been concerned with the mechanisms of transportation and deposition of sand into deep water environments but only a few have attempted studies of conglomerates. This is a result of several factors. Conglomerates are relatively uncommon in the geological record and they are intractable experimentally. Also, geologists have been unable to decide which attributes of conglomerates are the most important as indicators of transport mechanisms. Obviously the sedimentary structures associated with conglomerate deposits can provide some information about the origin of these deposits. Grain orientation and imbrication, and cross-stratification can provide palaeocurrent directions and possibly information on the mode of deposition of the rocks.

Several mechanisms have been proposed for the emplacement of coarse grained deposits in deep water environments. Some authors have stressed the importance of fluid turbulence, whereas others have stressed slump-slide mechanisms. The formulation of a model of deposition for any rock type must take into account the sedimentological characteristics of the rock type. In this study, emphasis has been placed on the description of the sedimentological characteristics of a conglomerate deposit, in the hope that these characteristics will provide some information on the importance of either fluid turbulence or slump-slide mechanisms during the deposition of the rocks.

The conglomerate outcrop at St. Simon (Fig. 1) was chosen because a previous study (Mathey, 1970) had established the stratigraphical succession and nomenclature. Also, the exposure was such that lateral and vertical changes in the conglomerates could be easily seen.

Previous Studies of Cambro-Ordovician Conglomerates in Québec

Previous papers on the Cambro-Ordovician rocks in the Appalachians (Bailey and McInnes, 1893; Laverdiere and Morin, 1941), provided some descriptions of the conglomerates of the Québec Group which crop out along the south shore of the St. Lawrence. Osborne (1956) described the Québec Group in the Québec City area. He thought the conglomerates were originally deposited in shallow water, but were later resedimented into a deep water environment. He postulated that the site of origin of the conglomerates was either on the margin of the geosyncline or on unstable ridges within the geosyncline.

Hubert (1965) described some conglomerates in the Québec Group of the L'Islet-Kamouraska area (Fig. 1). The geometry of the conglomerate

Figure 1: Outline of the regional geology in the southern part of Québec. (Modified from Hubert et al., 1970.).

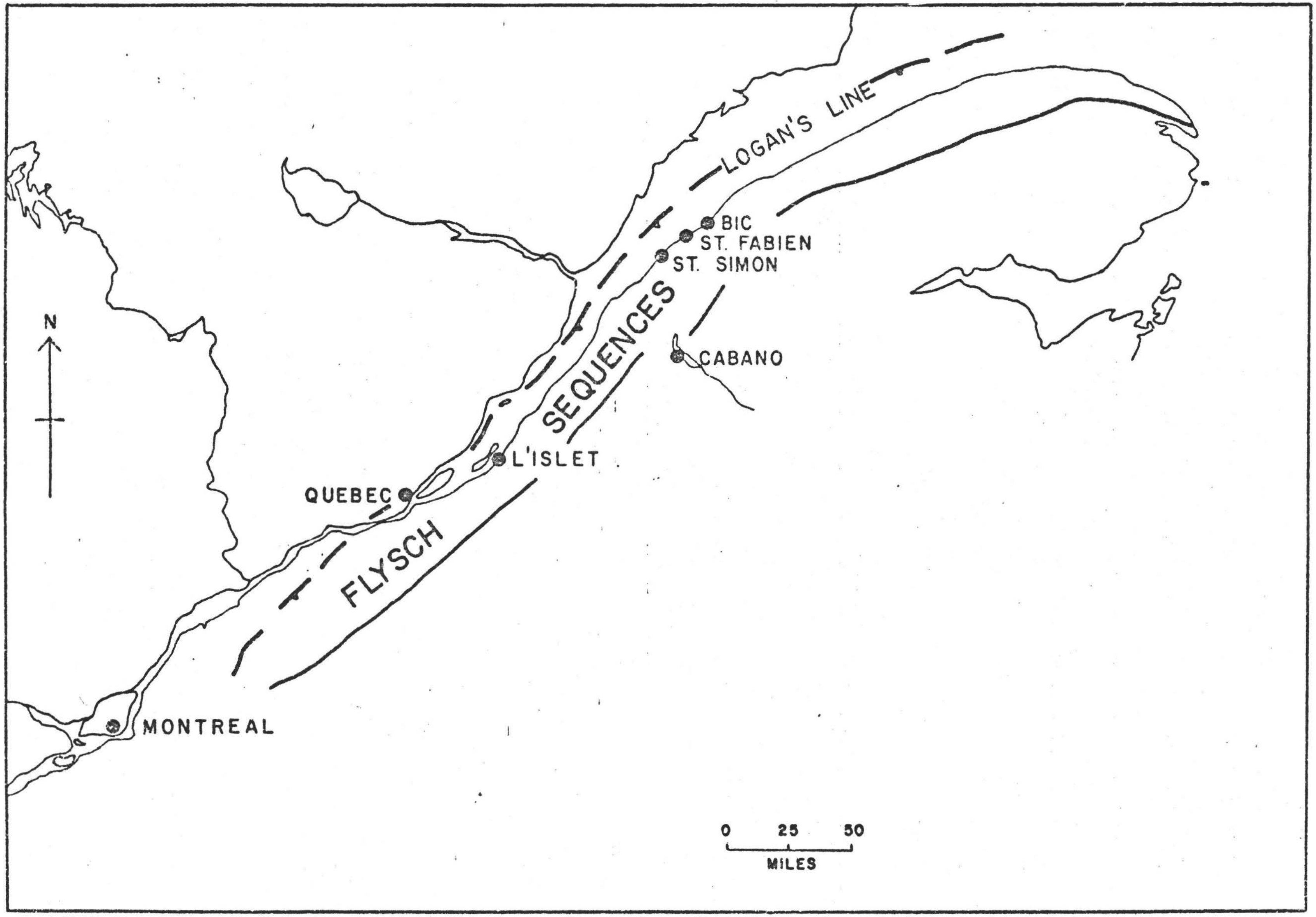

LOGAN'S LINE
BIC
ST. FABIEN
ST. SIMON
FLYSCH SEQUENCES
CABANO
N
L'ISLET
QUEBEC
MONTREAL
0 25 50
MILES

Figure 1

outcrops (in the St. Roch and St. Damase Formations) and the distribution of maximum and mean grain sizes within them, suggested that the conglomerates were derived from the northwest. Palaeocurrent measurements taken from cross-bedding in the conglomerates and associated quartz bearing arkosic conglomerates indicate that the currents flowed from the northwest. Palaeocurrent measurements taken from cross-bedding and flute casts in the arkosic Armagh Formation at a lower level in the Québec Group, indicate that the currents flowed from the southeast and occasionally from the south and east.

Lesperance and Greiner (1969), recognized two conglomerate types in the Squatec-Cabano area (Fig. 1). One conglomerate type was thin bedded and interbedded with slates and siltstones, whereas the other was thick bedded and not associated with slates and siltstones. The thin bedded conglomerates possessed clasts with low sphericity and poor rounding. The thick bedded conglomerates possessed a well sorted matrix. Because of these differences they concluded that the thin bedded conglomerates were emplaced by a slide mechanism whereas the thick bedded ones were emplaced by turbidity currents.

Hubert et al. (1970) described two conglomerate deposits in the Québec Group. At L'Islet Wharf (Fig. 1), they described a channellized conglomerate-sandstone sequence which was deposited contemporaneously with a limestone-shale assemblage. Flute marks and channels in the conglomerate-sandstone assemblage indicate that the currents flowed from the north. In the Bic-St. Fabien area (Fig. 1), a conglomerate-sandstone assemblage (the Cap Enragé Formation) is underlain by at least 600 m of claystone and siltstone and is overlain by 1600 m of interbedded pelites and graded sandstones. The overall stratigraphic position suggests the conglomerate-sandstone sequence was deposited in deep water. Palaeocurrent directions indicate flow from the north. This study was also done on the Cap Enragé conglomerates, but evidence will be presented which suggests that palaeocurrents flowing towards the southwest were also operative when the conglomerate-sandstone assemblage was deposited.

Mathey (1970) described the geological succession of the Cap Enragé Formation at St. Simon, about twenty miles S.E. of Bic (Fig. 1). He considered the lower part of the St. Simon section (essentially mudstones, feldspathic sandstones and conglomerates) to be laterally equivalent to the St. Fabien sequence described by Hubert et al. (1970) (Table 1, p. 6). Mathey's palaeocurrent information for the Cap Enragé Formation in the St. Simon district was obtained from cross-stratification, channels and flutes in the associated feldspathic sandstones. Few readings were obtained from the conglomerate assemblages themselves. He recorded twenty-two measurements in which the direction and sense of the currents were known and nineteen in which only the directions were known. Mathey's palaeocurrent information for the entire section is shown in Table 2, p. 7. The vector mean (for the succession) from the twenty-two measurements (direction and sense known) was 172 degrees, that from the nineteen measurements (direction known) was 144 degrees. This is contrary to the palaeocurrent information on the Horizon 3 conglomerates presented here, which indicates flow from the northeast, parallel to, rather than perpendicular to the present tectonic trends.

It should be stressed that throughout this thesis Mathey's stratigraphic nomenclature will be followed. A comparison of all the

TABLE 1. COMPARISON OF THE STRATIGRAPHICAL NOMENCLATURE

Age	Lithologies	Stratigraphy At Bic (Hubert et al., 1970)	Stratigraphy At St. Simon (Mathey, 1970)	Stratigraphy At Bic (Lajoie In Press)
	Interbedded Pelites		8	Ladrière
	and Graded Sandstones	Ladrière	Niveaux 7	Formation
Lower		Formation	6	
Ordovician			5	Cap Enragé
	Quartzo-feldspathic	Cap Enragé 4	Niveau 4	Formation 3
	Sandstones	Formation		
Maximum	Petromict Conglom-	Cap Enragé 3	Niveau 3	Cap Enragé 2
Age	erates and Quartzo-	Formation 2		Formation
Middle	feldspathic Sandstones			
Cambrian	Quartzo-feldspathic	Cap Enragé 1	Niveau 2	Cap Enragé 1
	Sandstones	Formation		Formation
	Claystones and	Original	Niveau 1	Original
	Siltstones	Formation		Formation

TABLE 2. PALAEOCURRENT DATA FOR ST. SIMON

(Tabulated from Mathey, 1970)

Horizon	Direction and Sense Known			Direction Known	
	Cross-Stratification	Channels	Flute Cast	Channels	"Flutes"
8	160,150				
7	100				170
6	160,160, 160,140	185			
5				130,120, 010,010, 005	
4	230,260, 220				
3	200,185	180		160,150, 150,125, 020,015	
2		235,250, 220,140	140	170,160, 010,010, 000	
1	120,120, 115			130	140

schemes is given in Table 1.

Mathey (1970) recognized the following rock fragments in the conglomerates and sandstones at St. Simon; micritic, oolitic, sandy and glauconitic limestones, quartzo-feldspathic sandstone, diabase and gneiss. The sandstone beds contained (in decreasing order of abundance) quartz, potassium feldspar, plagioclase feldspars, micas, glauconite, zircon, tourmaline and garnet. The igneous and metamorphic rock fragments and the heavy minerals are similar to the assemblages present in the Grenville Province of the Canadian Shield. The sedimentary rock fragments are similar to the Cambrian rocks which crop out south of the St. Lawrence River. Mathey concludes that the conglomerate-sandstone assemblages at St. Simon were formed by currents which resedimented material derived from the Canadian Shield and a carbonate platform in an area to the north of St. Simon. Mathey did not decide on a mechanism for the deposition of the coarse grained deposits but he suggests that they form a part of a submarine fan.

A subsidiary purpose of the present study is to fit the palaeocurrent information from St. Simon into a larger Appalachian picture of the environment of deposition. Models have been proposed by Dewey and Bird (1970) and Hubert et al. (1970). For Lower Palaeozoic times, Dewey and Bird (1970) envisaged a wide continental shelf bordered by a low craton in the west. Hubert et al. (1970) proposed a slightly different model of sedimentation for the rocks at L'Islet and St. Fabien. For Cambro-Ordovician times they proposed a narrow continental shelf, cut by submarine canyons, and bordered by a region of fairly high relief. The mountainous region supplied quartzo-feldspathic material which was rounded on the narrow continental shelf. Periodically this material was carried down the submarine canyons and deposited on submarine fan complexes. The palaeocurrent information presented here suggests that parts of the Cambro-Ordovician fan complexes were constructed by currents which flowed parallel to the present tectonic axes.

The Area of Study

This study deals with the sedimentological characteristics of the Cap Enragé Formation (Québec Group) at St. Simon (Figs. 1 and 2). The Québec Group is part of the flysch sequence which crops out in the Gaspé Peninsula. In this area the flysch sequence is contained in a series of thrust slices. The age of the rocks within the thrust slices ranges from Lower Cambrian to Middle Ordovician. The sequences of rocks in the thrust slices are successively older from Logan's Line southward, the Middle Ordovician lying structurally below the Lower Ordovician, which is in turn covered by the Cambrian rocks (Hubert et al., 1970). The sequence in the St. Simon area is 600-700 m thick, and consists of an alternating series of conglomerate and feldspathic sandstone assemblages, with quartz sandstone assemblages and mudstone-siltstone assemblages. The sequence was subdivided by Mathey (1970) into ten informal stratigraphic horizons (Table 1). Horizon 3, described here, consists of conglomerates and feldspathic sandstones, with no siltstones and mudstones. It can be traced laterally from Trois Pistoles to Rimouski (40 miles). Perpendicular to strike the formation can be traced six miles south of the St. Lawrence River (Hubert et al., 1970). At Bic (the type area) the conglomerates of Mathey's Horizon 3 of the Cap Enragé Formation are about 18 m thick, but at St. Simon Horizon 3 is about 50 m thick.

The area is folded into tight parallel folds, whose axes trend S.W.-N.E. The outcrop described here is on the northern limb of one such fold, which has negligible plunge (Fig. 2). Along this limb, the beds

Figure 2: General geology of the St. Simon area. (Modified from Mathey, 1970.).

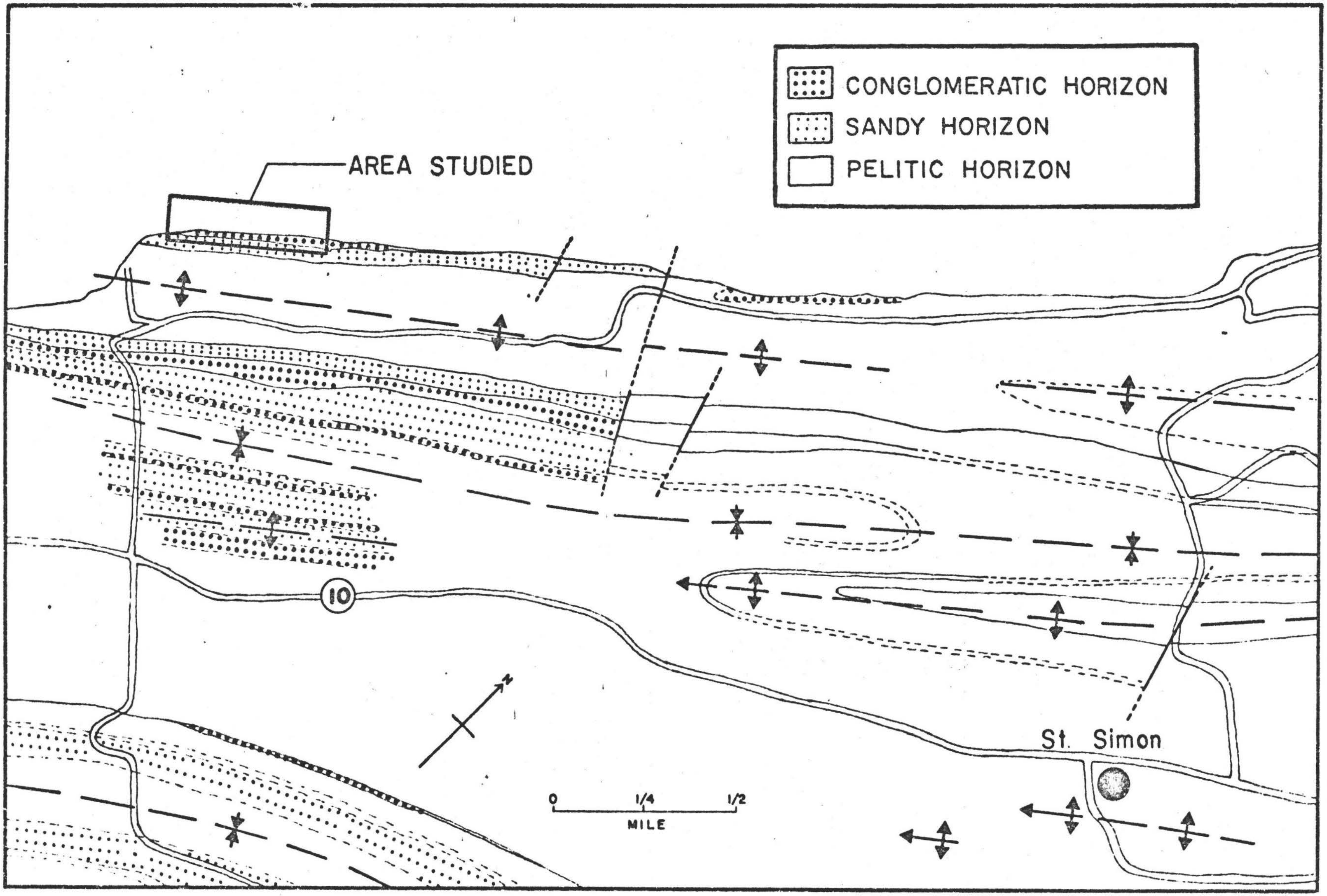

CONGLOMERATIC HORIZON
SANDY HORIZON
PELITIC HORIZON
AREA STUDIED
10
N
0
1/4
1/2
MILE
St. Simon

Figure 2

generally dip to the northwest at a high angle. Some beds are overturned and dip to the southeast. There are numerous small faults trending S.E.-N.W., whose throws vary from several centimetres to a few metres (Map 1).

Figure 3: Measured sections at six localities on the outcrop at St. Simon. The correlations are based upon facies similarity and the "walking out" of beds on the outcrop.

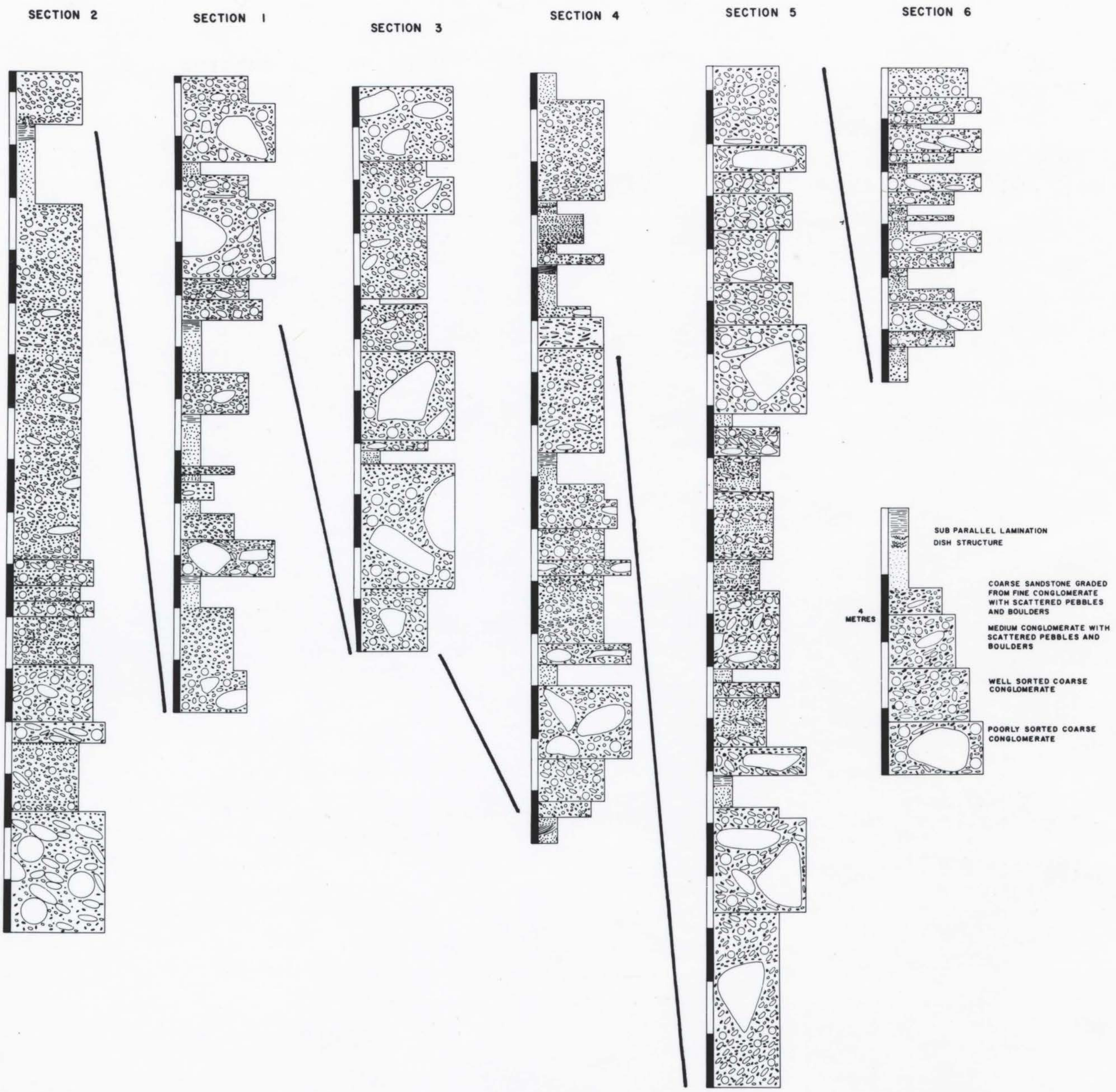

SECTION 2
SECTION 1
SECTION 3
SECTION 4
SECTION 5
SECTION 6
SUB PARALLEL LAMINATION
DISH STRUCTURE
COARSE SANDSTONE GRADED FROM FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
4 METRES
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
WELL SORTED COARSE CONGLOMERATE
POORLY SORTED COARSE CONGLOMERATE

Figure 3

CHAPTER 2

FIELDWORK

Mapping

Because a detailed study of the area was required, it was decided to map the outcrop at a scale of 1:100. An arbitrary zero bench mark was set up at the western end of the outcrop and distances were measured in metres along strike from this point. At intervals of 8-15 metres along the outcrop, substations were mapped by compass and tape and marked with white paint. These substations were used to locate positions on the outcrop.

At various distances along strike, stratigraphic sections through the sequence were measured (Figure 3). The position of these sections, and of photographs and samples, are shown on the map (Map 2).

During mapping, it became apparent that there were several facies exposed. The facies range from coarse conglomerates to fine conglomerates and sandstones (Chapter 3). Combinations of the facies define three fining upward sequences (compare Maps 1 and 2). Coarse conglomerates are prominent at the base of each fining upward sequence, whereas at the top of each sequence fine conglomerates and sandstones are prominent. The fieldwork carried out was aimed at determining the character and extent of the facies within the fining upward sequences.

Grain Orientations

After a reconnaissance of the outcrop, made during the first field mapping season, it was apparent that many of the beds contained grains with a preferred a-axis orientation. On bedding surfaces the preferred a-axis orientation is called "grain orientation" and in sections perpendicular to bedding it is called "imbrication". Reconnaissance also showed that grain orientation and imbrication data could be obtained from photographs. A large number of surfaces in the outcrop could not be used for orientation studies for several reasons. Some surfaces were cleaved, others were oblique to bedding and other surfaces lacked contrast. Those surfaces which were covered with slime were cleaned with a wire brush before they were photographed. Where it was decided that a surface was photographable, the directions of dip and strike and a suitable scale were drawn on the surface. The location of the surface, the direction and amount of dip, the way up direction and the type of surface were recorded. Two faces perpendicular to bedding, one parallel to strike and one transverse to strike, were examined in order to estimate the 3-D imbrication as close as possible to the location of each orientation photograph. In some cases, this was not possible. The surfaces were photographed at a distance of approximately one metre.

20 x 25 cm prints were made and covered with tracing paper. Equispaced lines, which did not intersect the same grain twice, were drawn at right angles to the direction of strike. The print and the affixed tracing paper were mounted on a light table. The long axes of grains which fell on the equispaced lines were drawn according to the least projection elongation method. The long axes were drawn only for grains which were not broken and which possessed sharp boundaries. (Elongate grains are those which possess an apparent axial ratio a/b

greater than 1.5.). After one hundred long axes had been drawn by the author, the tracing paper was removed from the print and the angles of the long axes were measured with reference to strike by student assistants. A vector mean and vector strength were computed for each sample.

Imbrication

Reconnaissance showed that only those faces roughly parallel to the present strike exhibited imbrication. No preferred pebble fabric could be demonstrated on faces perpendicular to the present strike. To record imbrication information, a tape measure was placed at the top of the bed in such a way that the centimetre values on the tape decreased eastwards. The tape was parallel to regional bedding. The surfaces were photographed at a distance of approximately one metre and the location of each photograph was recorded. The long axes of the grains were drawn using the same method as outlined for the grain orientations.

Two sets of data were recorded. The first set contained one hundred readings obtained from all elongate grains regardless of size. (An elongate grain is one which possesses an apparent axial ratio a/c greater than 1.5.). The second set was obtained from either fifty or twenty-five elongate grains longer than three centimetres. The number of grains measured in the second set of data was controlled by the number of grains on the print. If there were less than fifty grains on the print, only twenty-five were measured. The vector mean and vector strength were computed for each outcrop.

Roundness

After examination of the outcrop, it was decided that grain roundness measurements could be obtained by using the method of Dobkins and Folk (1970). On a suitable basal surface the apparent roundness of a grain was measured by comparing the diameter of curvature of the sharpest corner visible with the diameter of the largest inscribed circle to fit the grain. One hundred apparent roundness measurements were calculated at each outcrop (Appendix 1). In this work, all the roundness measurements quoted are apparent roundness measurements.

Elongation

The apparent elongation of a grain is computed as:

$$\frac{\text{apparent length of a-axis}}{\text{apparent length of c-axis}}.$$

A grid system for sampling was set up at several localities and the apparent elongation of at least one hundred grains was calculated (Appendix 2).

Measurements of the Ten Largest Clasts

In order to see if there was an appreciable change of maximum clast size up through the section, and if there was any relationship between clast size and lithology, it was decided to measure the diameter of the ten largest limestone and ten largest sandstone clasts present at various horizons. The mean size of the ten largest clasts was regarded as an approximation to the coarsest material that could be transported by the currents. For convenience, the "average diameter of the ten largest clasts" will be symbolized as D/10.

Composition

The compositions of the conglomerates were estimated using a grid system. The grid consisted of parallel equispaced lines, of equal length, which were drawn on the outcrop. The lithology and the length of intersection of each grain (with an apparent a-axis longer than 1 mm) along the lines of the grid system were recorded. Those grains with an apparent a-axis less than 1 mm were recorded as matrix. The total lengths of the grid systems differed from facies to facies. In coarse conglomerates the lengths of the grid systems were about 5 m, in the medium conglomerates the lengths were about 3 m.

CHAPTER 3

Facies Definition and Description

During field mapping it was noticed that there was a wide range of clast size in the conglomerates. The clast size (apparent length of the a-axis) seemed to be the most characteristic property of the conglomerates and for this reason it was decided to subdivide the sequence into four lithologies;

coarse conglomerate, a-axis > 4 cm

medium conglomerate, a-axis 1.5-4 cm

fine conglomerate, a-axis 0.5-1.5 cm

coarse sandstone, a-axis < 0.5 cm.

The range of clast size, degree of sorting, and the amount of coarse sandstone within a certain stratigraphic thickness were sufficient to define a "facies", that is, a restricted part of the stratigraphic succession which is different in aspect from adjacent parts of the succession. The facies are:

Coarse Conglomerate, Poorly Sorted

Coarse Conglomerate, Well Sorted

Medium Conglomerate with Scattered Pebbles and Boulders[1]

---

[1]In this work pebbles are clasts which have an apparent a-axis 4-25 cm long and boulders have an apparent a-axis > 25 cm long.

Fine Conglomerate with Scattered Pebbles and Boulders

Coarse Sandstones.

The poorly sorted conglomerates have more, and larger boulders than the well sorted conglomerates (compare Figs. 8 and 24). The types of occurrence of the facies are shown in Table 3, p. 20.

The coarse and medium conglomerate beds commonly have thin (< 10 cm) layers of finer grain size at the top. These thin layers were not mapped individually and are not included in Table 3, although they are described under the appropriate facies headings. Lateral variations in the facies were not as prominent as the vertical ones. The concentration of coarse conglomerate clasts varied laterally in some units. In such cases the prominent lithology defined the facies for basic mapping and descriptive purposes.

In this work, within-facies layering shown up by changes in the proportion of different grain sizes is defined as stratification. The stratifications in the medium conglomerate are generally thicker than those in the fine conglomerates.

It was noticed that combinations of the facies defined three overall fining upward sequences (compare Maps 1 and 2). Several generalizations can be drawn about these sequences. Either or both of the coarse conglomerate facies occur near the base. The percentage of coarse conglomerate decreases upwards in the first and second sequence but near the top of the third, thin coarse conglomerates occur. The coarse conglomerates are usually succeeded by medium conglomerates. In the first and second sequences the percentage of medium and fine conglomerate increases upwards. The top of each sequence is marked by a thick

TABLE 3. TYPES OF OCCURRENCE OF THE FACIES

Types Of Occurrence Of The Facies	Basal Inverse Grading, Main Part Of The Bed Structureless	Basal Inverse Grading, Main Part Of The Bed Normally Graded	Normal And Inverse Grading At The Base, Main Part Of The Bed Normally Graded	Whole Bed Normally Graded	Whole Bed Stratified	Bed Partly Stratified	No Structure At All
Coarse Conglomerate, Poorly Sorted							
Individual Beds Of Coarse Conglomerate	4	5		3			
Coarse Conglomerate Grading To Medium Conglomerate With Scattered Pebbles And Boulders			1				
Coarse Conglomerate Grading To Coarse Sandstone	4						
Coarse Conglomerate, Well Sorted							
Individual Beds Of Coarse Conglomerate	1	2	3	2	2		
Coarse Conglomerate Grading To Medium Conglomerate And Coarse Sandstone			1				
Medium Conglomerate With Scattered Pebbles And Boulders							
Individual Beds Of Medium Conglomerate					16		13
Medium Conglomerate Grading To Fine Conglomerate And Coarse Sandstone							1
Medium Conglomerate Grading To Coarse Sandstone					4		1
Fine Conglomerate With Scattered Pebbles And Boulders							
Individual Beds Of Fine Conglomerate					3		
Fine Conglomerate Grading To Coarse Sandstones				4			
Coarse Sandstones							
Individual Beds Of Coarse Sandstone						5	1

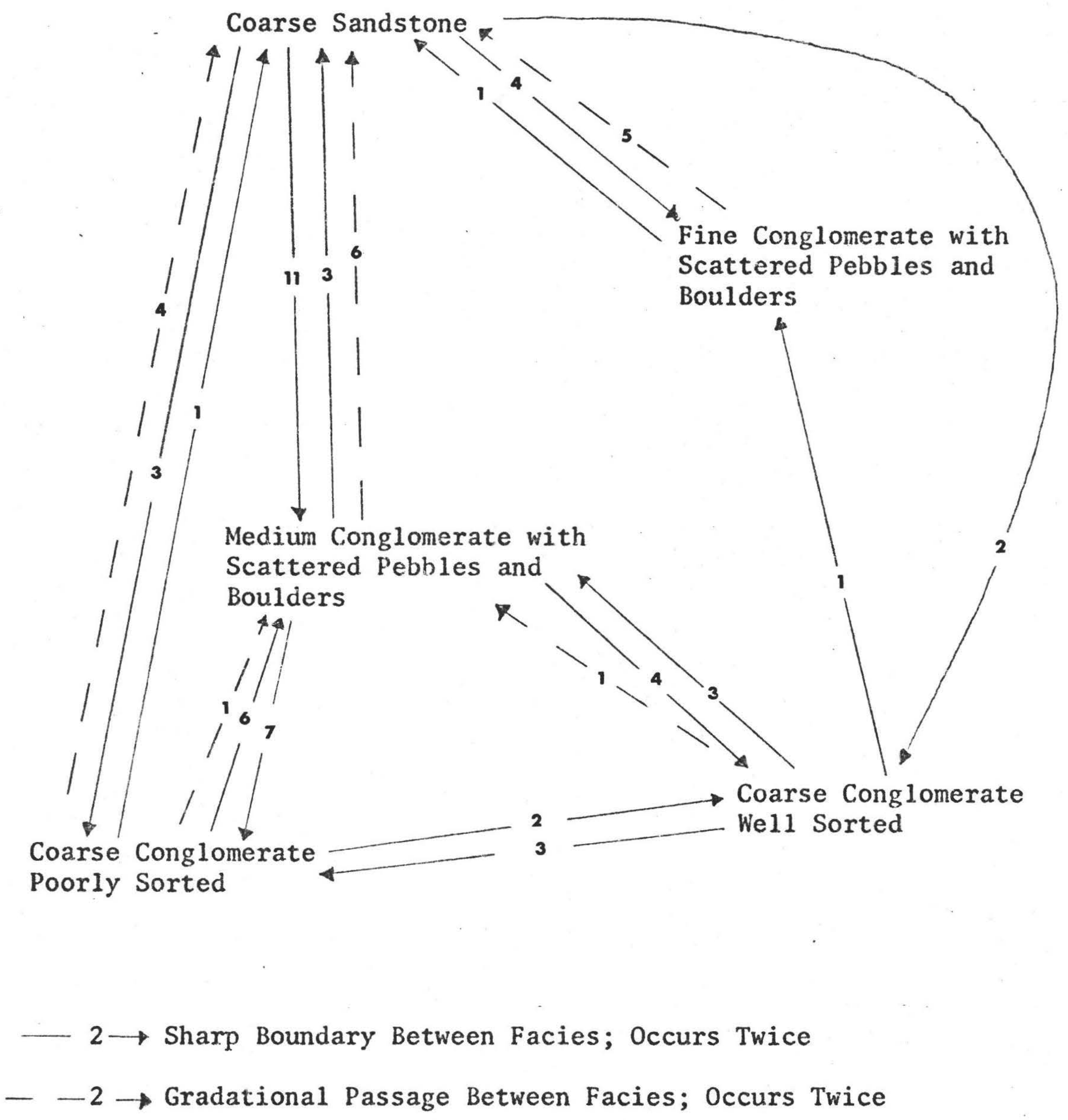


Figure 4: Facies relationship diagram for the entire section at St. Simon to show the type of boundary between the facies and the number of times the facies are in vertical contact with each other. (Modified from De Raaf et al., 1965.).

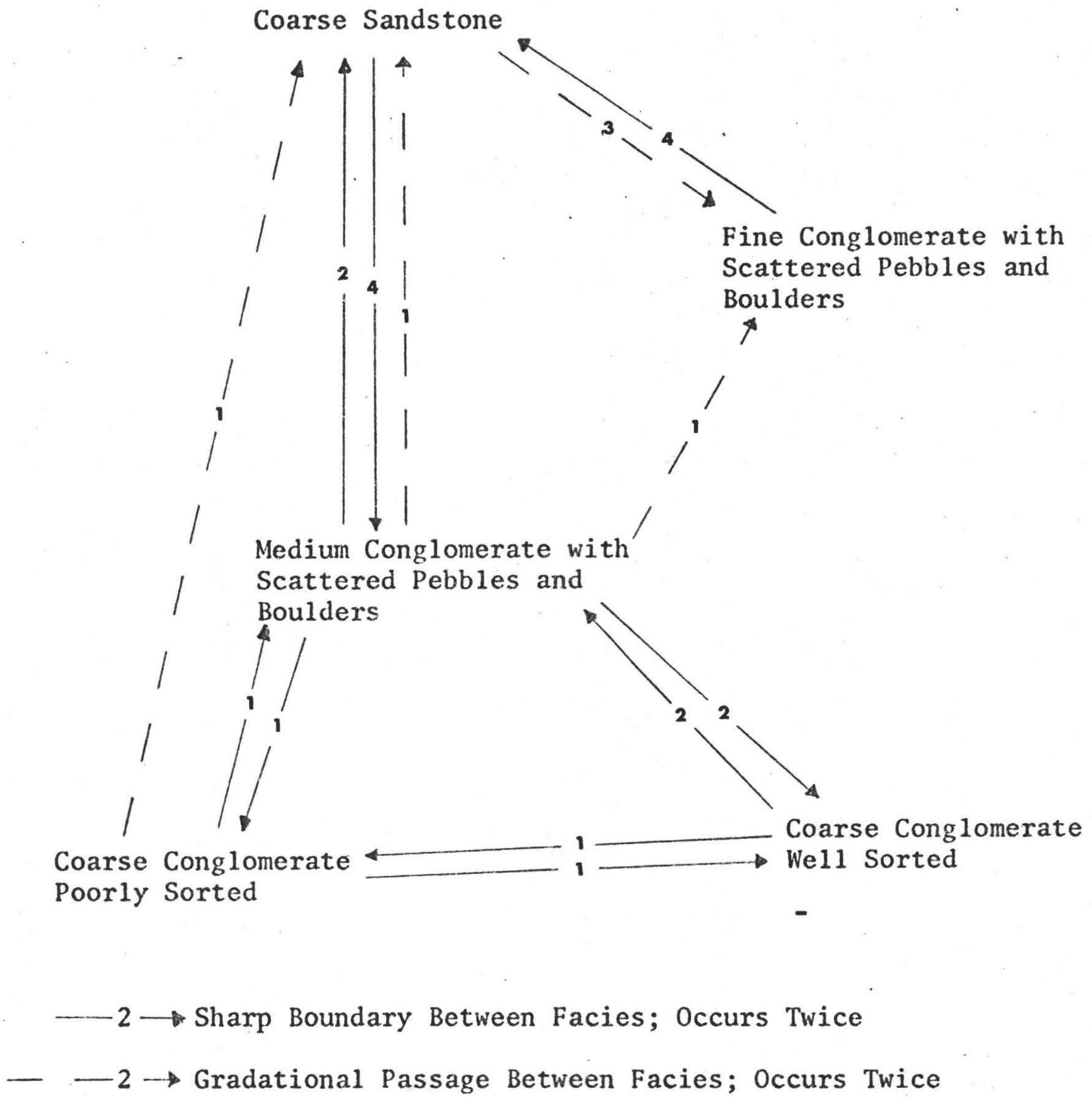
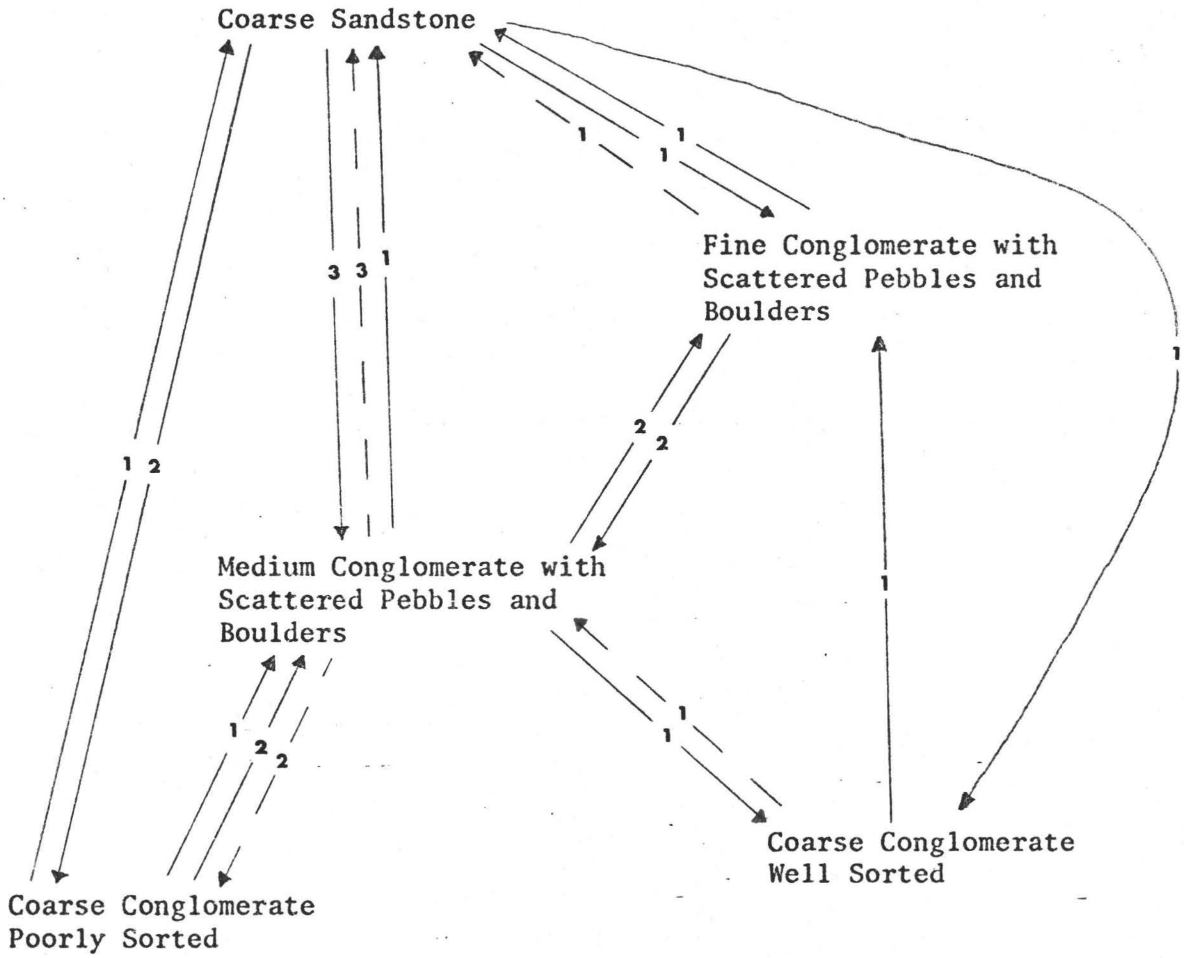


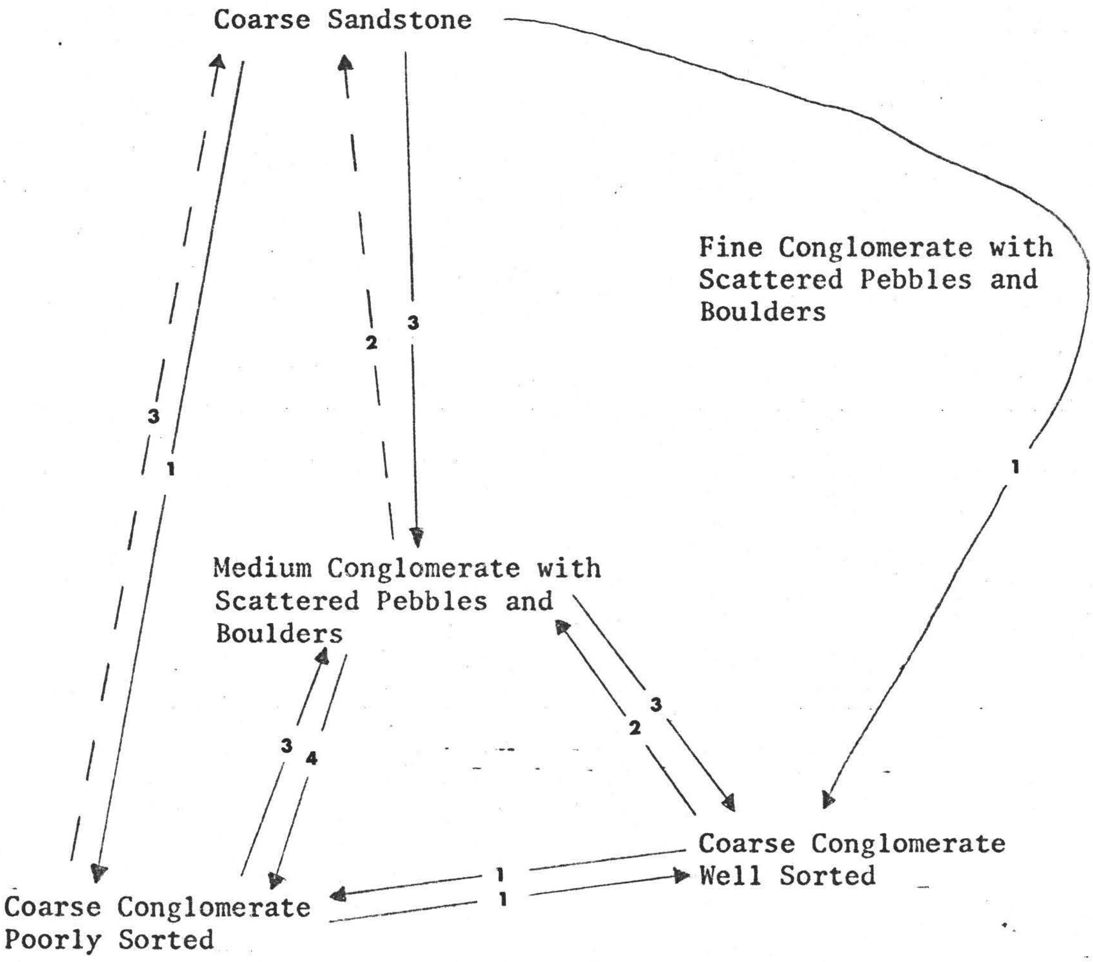
Figure 5: Facies relationship for the first fining upward sequence at St. Simon to show the type of boundary between the facies and the number of times the facies are in vertical contact with each other. (Modified from De Raaf et al., 1965.).



——— 2 ——→ Sharp Boundary Between Facies; Occurs Twice

— —2 —→ Gradational Passage Between Facies; Occurs Twice

Figure 6: Facies relationship for the second fining upward sequence at St. Simon to show the type of boundary between the facies and the number of times the facies are in vertical contact with each other. (Modified from De Raaf et al., 1965.).



——— 2 ——▸ Sharp Boundary Between Facies; Occurs Twice

— — 2 —▸ Gradational Passage Between Facies; Occurs Twice

Figure 7: Facies relationship for the third fining upward sequence at St. Simon to show the type of boundary between the facies and the number of times the facies are in vertical contact with each other. (Modified from De Raaf et al., 1965.).

sandstone, and in all the sequences the percentage of sandstone increases near the top. The thickest sandstones are in the first sequence, the thinnest and most persistent laterally are in the third. The facies relationships within the entire section and within each of the three fining upward sequences are shown in Figures 4-7, p. 21-24.

Coarse Conglomerate, Poorly Sorted

General Features

This facies comprises 25 percent of the entire section (Fig. 8). The types of occurrence of the facies are shown in Table 4, p. 26. The average bed thickness is about 80 cm, with beds ranging from 20 cm to 2 m (Map 1). Generally, the bases of the beds are flat and sharp, but 30 percent have channels or scours up to 1 m deep (Fig. 9). Individual beds are difficult to trace because of faulting. However, groups of beds (up to 4 m thick) can be correlated laterally for 400 m parallel to the inferred direction of flow. Within areas in which individual beds can be walked out, there is no evidence for "shingling", that is, the building forward of successive beds in partly-overlapping wedges. Twenty percent of the beds have load structures. The conglomerates load to a depth of 3-4 cm for several metres along the underlying sandstones (Fig. 10). The largest clast (250 cm) is in the first fining upward sequence (Bed 16B, Map 1) but the maximum D/10 (88 cm) is in the second fining upward sequence (Appendix 3, Bed 26, Fig. 11, Map 3). In the field about half the beds appear to have a bimodal grain size distribution, with modes of about 6 and 11 cm. A subordinate coarser modal class of about 20-30 cm was also noted. There is no correlation between clast size and lithology.

TABLE 4. TYPES OF OCCURRENCE OF THE FACIES
(Coarse Conglomerate, Poorly Sorted)

Types Of Occurrence Of The Facies	Basal Inverse Grading, Main Part Of The Bed Structureless	Basal Inverse Grading, Main Part Of The Bed Normally Graded	Normal And Inverse Grading At The Base, Main Part Of The Bed Normally Graded	Whole Bed Normally Graded
Individual Beds Of Coarse Conglomerate	4	5		3
Coarse Conglomerate Grading To Medium Conglomerate With Scattered Pebbles And Boulders			1	
Coarse Conglomerate Grading To Coarse Sandstone	4			

Figure 8: Outcrop of poorly sorted coarse conglomerate.

Figure 9: Channellized outcrop of poorly sorted coarse conglomerate.

Figure 10. Poorly sorted coarse conglomerate loaded in coarse sandstone.

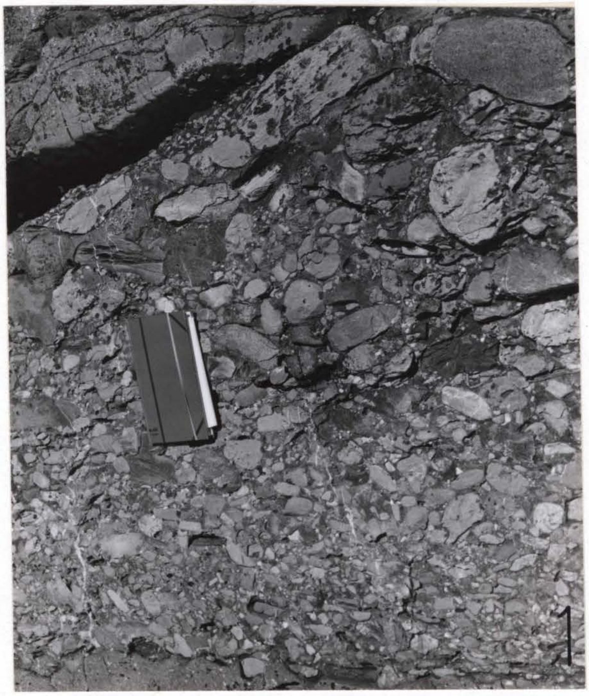


Figure 12: Inversely graded poorly sorted coarse conglomerate.

Figure 11: Distribution of D/10 measurements throughout the entire section.

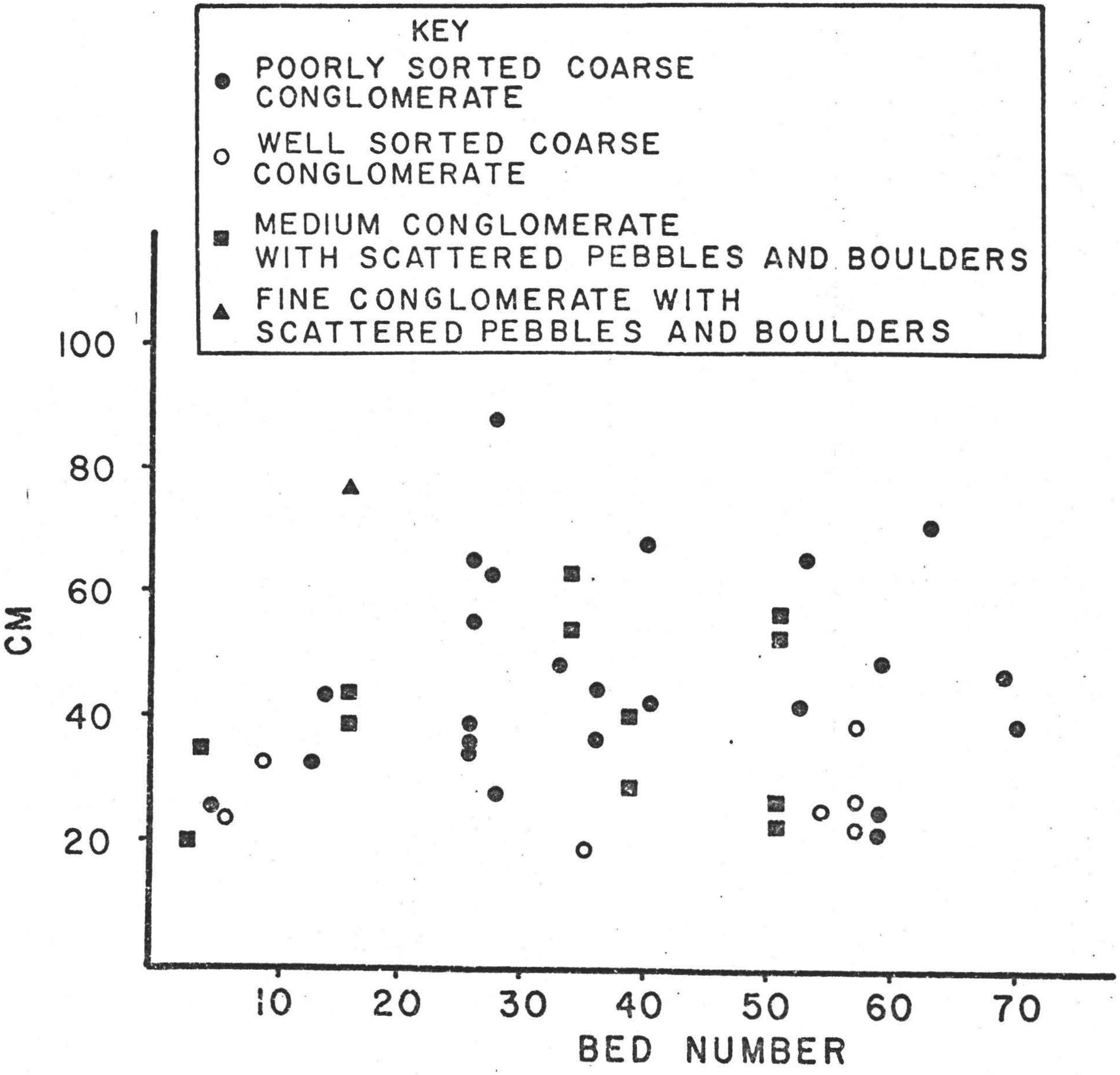

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
CM
100
80
60
40
20
10
20
30
40
50
60
70
BED NUMBER

Figure 11

Internal Structures

The occurrence of the various internal structures is shown in Table 4, at the beginning of this facies description (p. 26). In those beds which display basal inverse grading, the grading is generally confined to within 15 cm of the base (Fig. 12), but in some beds it occurs up to 30 cm from the base. The inversely graded portion is medium conglomerate but pebbles and boulders occur. There is a gradual increase in the percentage of pebbles and boulders upwards, and the facies becomes a coarse conglomerate. Where the normal and inverse grading occur together, the inverse grading may extend laterally for 5 m before it is replaced by normal grading. The change from inverse to normal grading is shown up by an increase in the number of pebbles and boulders at the base of the bed. All the individual beds have thin developments of medium and fine conglomerates at their tops. The medium and fine conglomerates are not stratified.

The coarse portion of the facies is never stratified. A common feature of the coarse portion is the concentration of pebbles in linear or arcuate zones (Fig. 13). In the zones the pebbles are imbricate but do not overlap each other for any considerable length (less than 3 cm). The zones, which persist for one or two metres, dip east and west.

Composition

The composition of the facies, which is relatively constant, is summarized in Table 5, p. 31 (Figs. 14-17, Map 2, Appendix 4). The low percentage of matrix suggests the facies is grain supported. In one third of the beds the percentage of quartz increases near the top. The

TABLE 5. SUMMARY OF THE COMPOSITION OF THE FACIES[2]
(Coarse Conglomerate, Poorly Sorted)

Constituent	Range (%) Throughout The Section (Bed And Sequence Nos. In Parenthesis)	Range (%) Within The Sequences (Bed And Sequence Nos. In Parenthesis)
Sandstone	16(63,3) - 27(2,1)	16(63,3) - 21(65,3)
Quartz	1(65,3) - 9(36,2)	2(33,2) - 9(36,2)
Micrite	27(33,2) - 38(63,3)	28(65,3) - 38(63,3)
Matrix	11(65,3) - 22(63,3)	12(33,2) - 15(36,2)

[2]All those grains with apparent a-axes less than 1 mm were classed as matrix.

Figure 13: Pebble zones in the poorly sorted coarse conglomerate. The pebble zone is the arcuate feature extending from the top right-hand to the top left-hand corner of the figure.

Figure 14: Range of the percentage of micrite clasts contained within the facies.

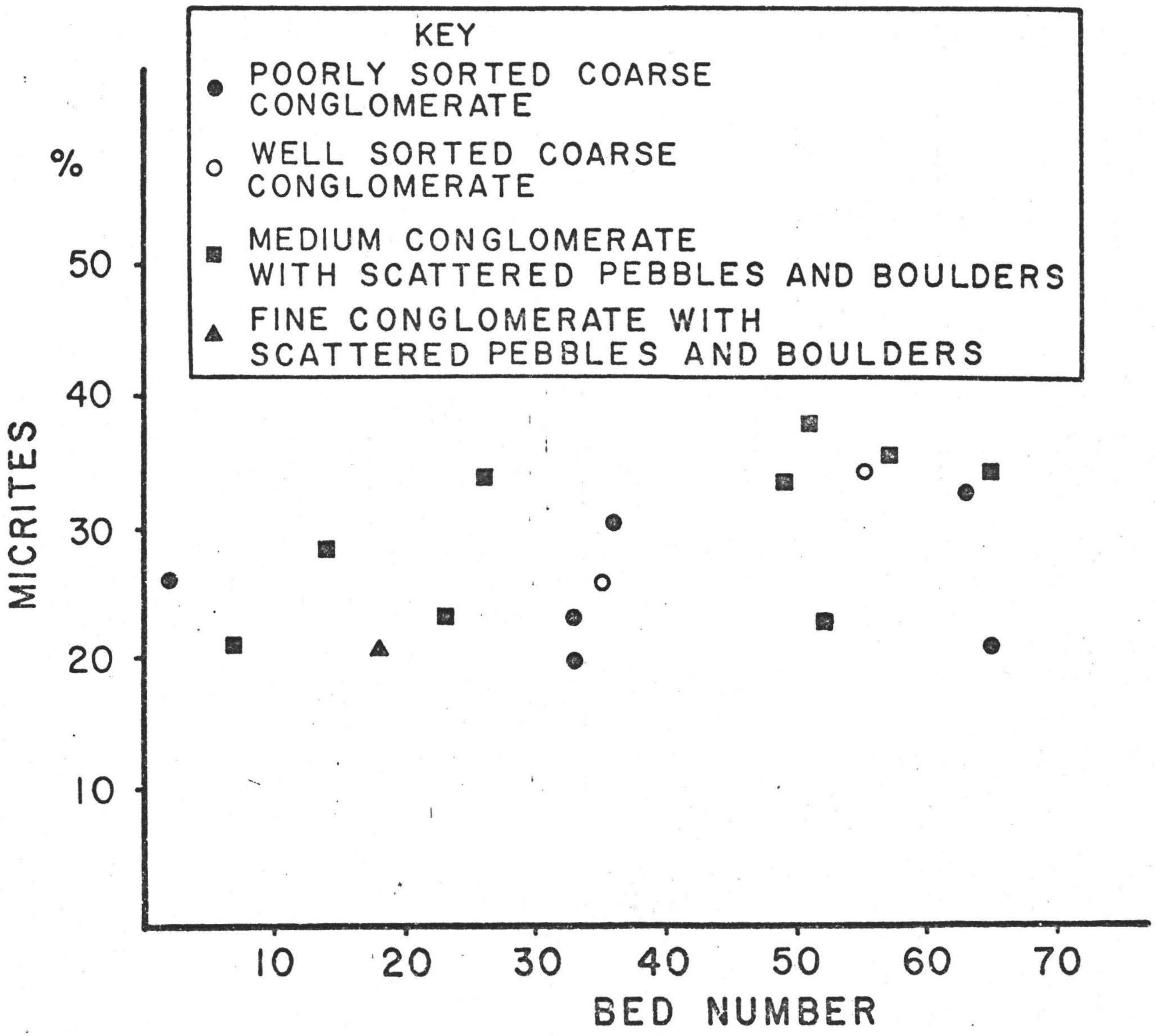

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
%
MICRITES
50
40
30
20
10
10
20
30
40
50
60
70
BED NUMBER

Figure 14

Figure 15: Range of the percentage of sandstone clasts contained within the facies.

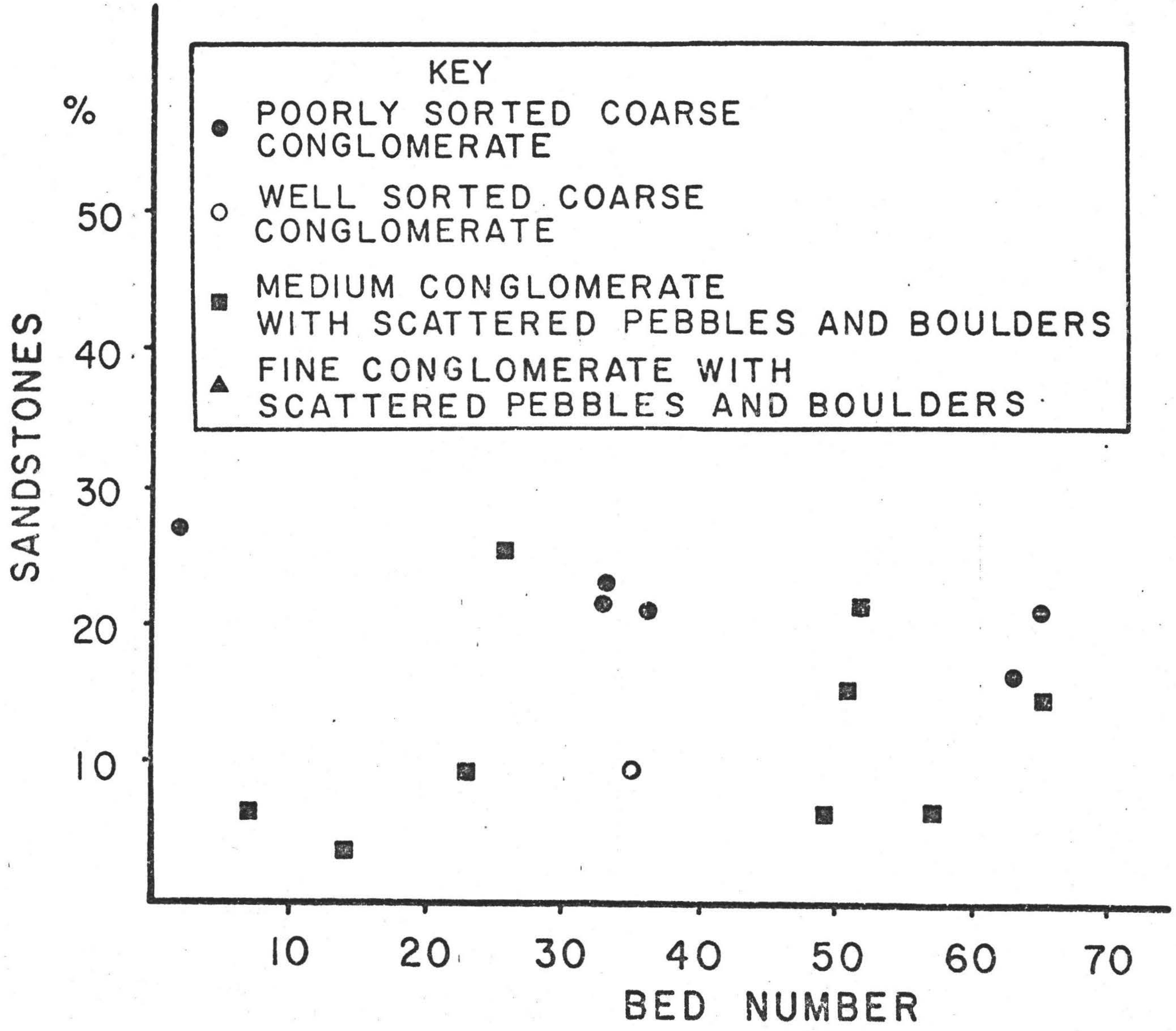

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
% SANDSTONES
10
20
30
40
50
10
20
30
40
50
60
70
BED NUMBER

Figure 15

Figure 16: Range of the percentage of quartz clasts contained within the facies.

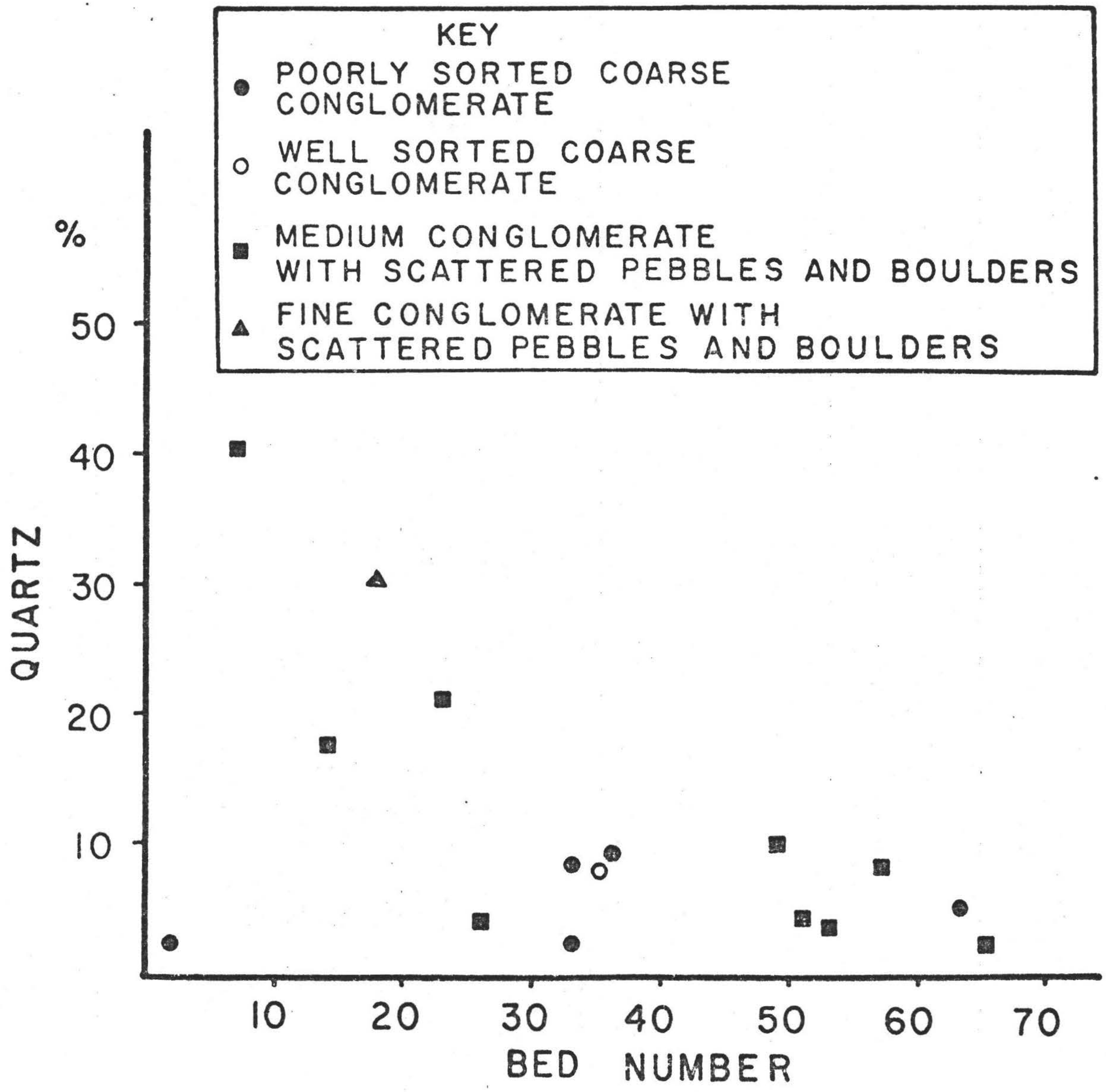

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
% QUARTZ
50
40
30
20
10
10
20
30
40
50
60
70
BED NUMBER

Figure 16

Figure 17: Range of the percentage of matrix contained within the facies.

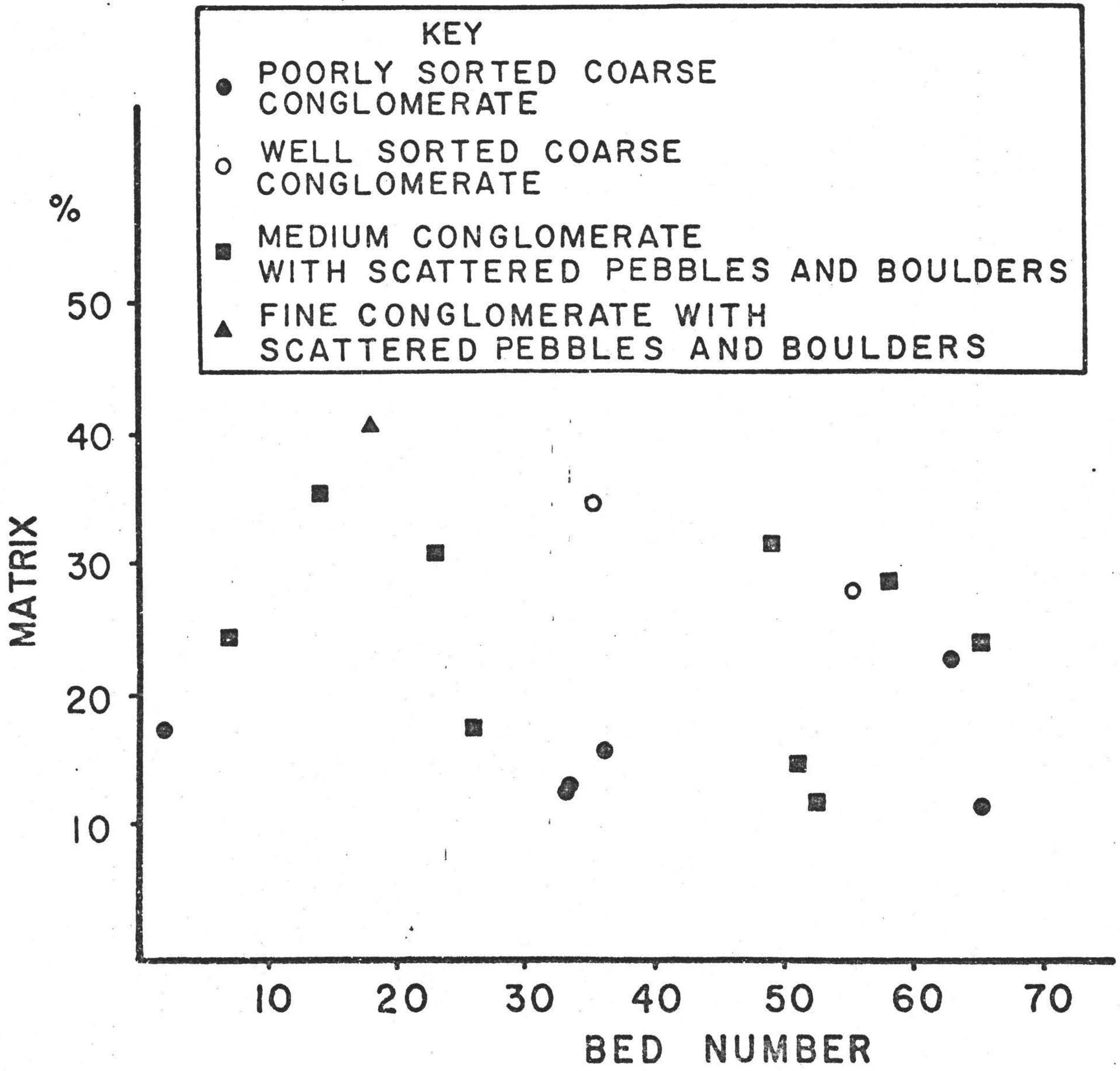

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
% MATRIX
50
40
30
20
10
10
20
30
40
50
60
70
BED NUMBER

Figure 17

increase is a rapid one, occurring within 15 cm. The quartz grains near the base of the bed are coarser than those near the top. The lithologies of the coarse conglomerate clasts are; black and green meta-limestones, parallel and cross-laminated sandy limestones, grey micrites, pisolitic limestones, bioclastic limestones, calcite cemented medium grained cream sandstones with rounded quartz grains, calcite cemented medium grained cream sandstones and light grey fine grained sandstones. Some groups of beds are characterized by certain lithologies. Within the second fining upward sequence, one group (Beds 26-28, Map 1) characterized by cream sandstone clasts can be traced laterally for 400 m.

Roundness and Elongation

A roundness study of one hundred grains on the base of one bed at one locality gives an average apparent roundness of 0.40 (Dobkins and Folk, 1970) (Bed 1, Map 3, Appendix 1). Clast roundness ranges from well rounded to angular (Fig. 18).

Within one bed no consistent change of elongation occurs vertically. Also, no consistent change of the average elongation index (the average of the elongation measurements at one locality) occur throughout the section. The index ranges from 2.2 to 2.6 (Beds 63 and 36, Map 3, Appendix 2).

Imbrication

Measurements of the well developed easterly dipping imbrication do not reveal any apparent change of angle vertically or laterally within the section (Map 4, Figs. 19-20, Appendix 5). Generally, the imbricate grains are separated by smaller grains (apparent a-axis of 1 cm and less) and matrix (Fig. 21). Where imbricate grains are in contact, the contacts are usually less than 3 cm long. The measurements of imbrication are summarized in Table 6.

TABLE 6. SUMMARY OF THE IMBRICATION MEASUREMENTS (Coarse Conglomerate, Poorly Sorted)

No. Of Grains	Range (In Degrees) Of Imbrication (Bed And Sequence Nos. In Parenthesis)
100	1(40,2) to 8(59,3)
50	6(40,2) to 14(26,2)

The smaller grains possess a more random imbrication, filling the spaces between the larger clasts (Fig. 22). The direction of imbrication of the small clasts changes near very large clasts (Fig. 23). Within-bed angles of imbrication are laterally variable, ranging from 11 to 14 degrees and 6 to 8 degrees (Beds 26 and 40, Map 4). Towards the top of many beds, the imbrication dies out and flat lying grains increase in proportion. The flat lying grains are less than 3 cm long and are separated by coarse sand and matrix.

Three reversals of imbrication, that is, grains with their long axes dipping westward, occur in the second fining upward sequence (Bed 40, Map 4). The angles of imbrication of 2, 6 and 1 degrees are on the same bed but eight and 130 m apart respectively. Also on the same bed, imbrications (grains with long axes dipping eastward) of 1 degree (measured from one hundred grains), 6 and 8 degrees (measured from fifty and twenty-five grains respectively) are recorded. Another reversal of

Figure 18: Range of clast roundness within the poorly sorted coarse conglomerates.

Figure 21: Imbricated poorly sorted coarse conglomerate.

Figure 19: Imbrication measurements obtained from one hundred grains.

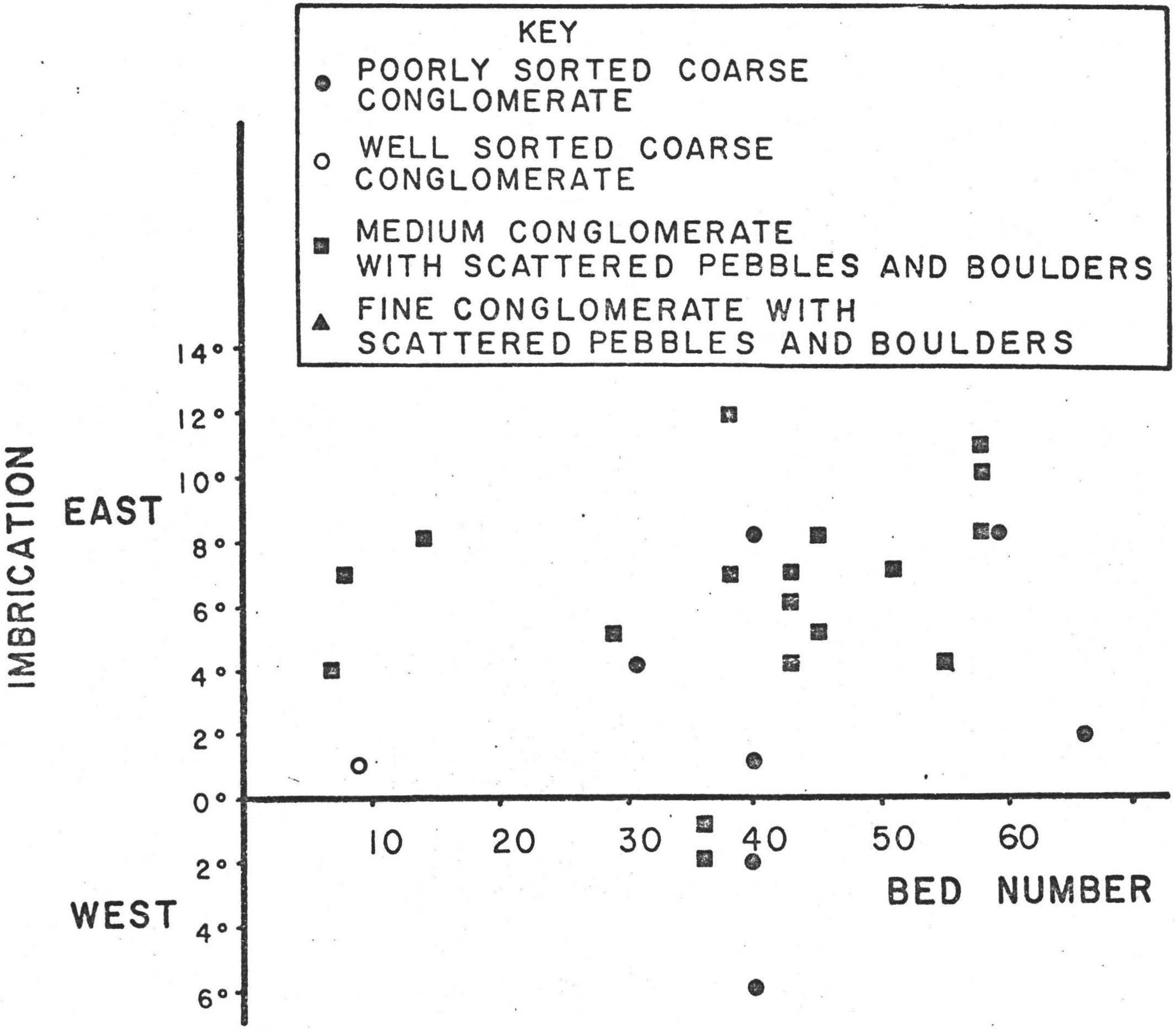

KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
IMBRICATION
EAST
WEST
14°
12°
10°
8°
6°
4°
2°
0°
2°
4°
6°
10
20
30
40
50
60
BED NUMBER

Figure 19

Figure 20: Imbrication measurements obtained from fifty and twenty-five grains.

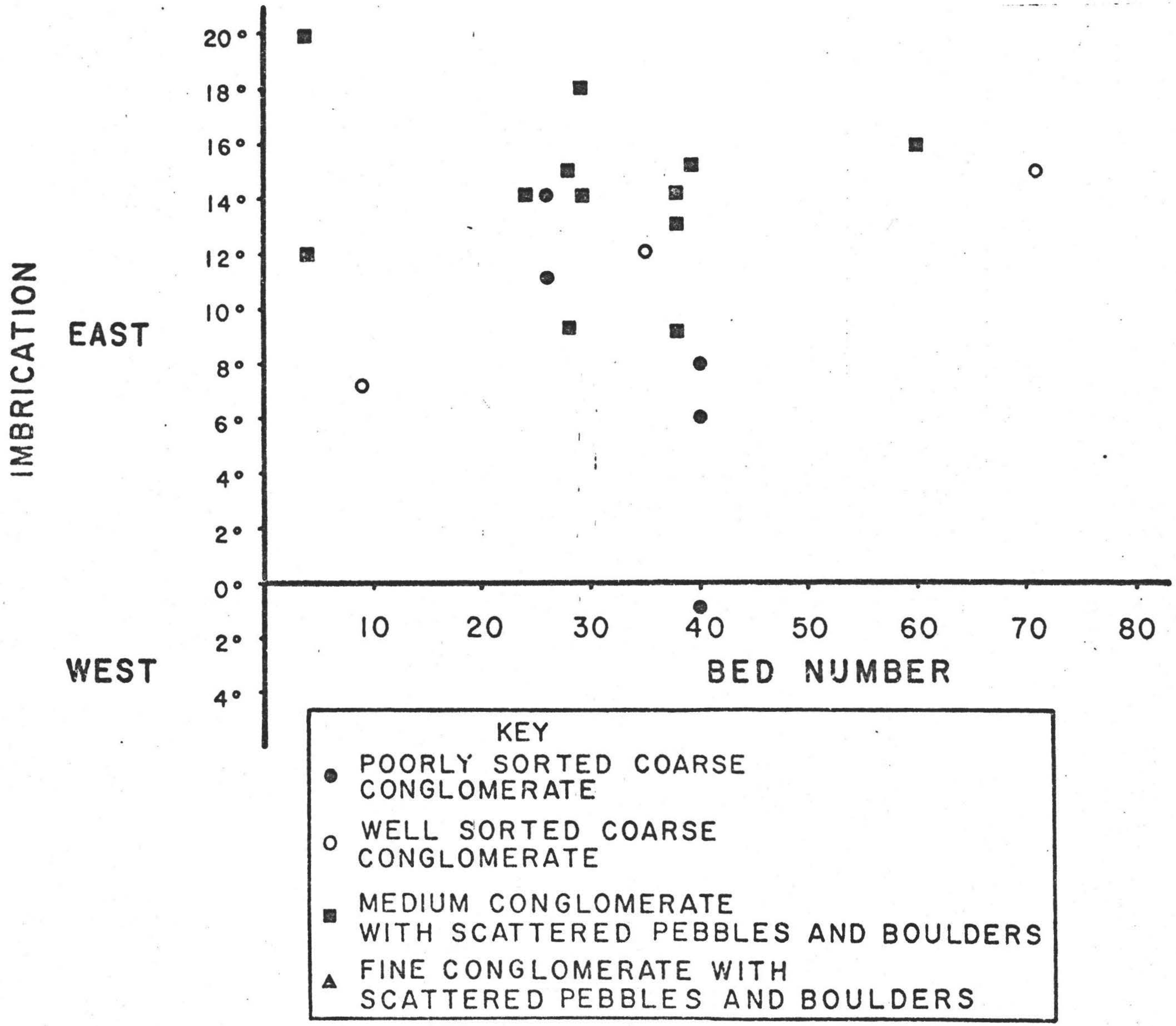

IMBRICATION
EAST
WEST
20°
18°
16°
14°
12°
10°
8°
6°
4°
2°
0°
2°
4°
10
20
30
40
50
60
70
80
BED NUMBER
KEY
POORLY SORTED COARSE CONGLOMERATE
WELL SORTED COARSE CONGLOMERATE
MEDIUM CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS
FINE CONGLOMERATE WITH SCATTERED PEBBLES AND BOULDERS

Figure 20

imbrication (long axis dipping westward) occurs in Bed 36 about 20 m east of those measured in Bed 40 (Map 4).

Coarse Conglomerate, Well Sorted

General Features

This facies comprises about 7 percent of the entire section (Fig. 24). The types of occurrence of the facies are shown in Table 7, p. 44. The average bed thickness is about 60 cm with beds ranging from 20 to 185 cm. Sixty percent of the beds have flat, sharp bases and 40 percent have channels or scours up to 60 cm deep. It is difficult to trace individual beds along strike because of faulting. The beds, which can be traced laterally for 40 m, do not appear to be shingled. No slump or load structures are visible in the facies.

The largest clast (76 cm) is in the third fining upward sequence (Bed 70) but the maximum D/10 is in the second fining upward sequence (39 cm) (Bed 57, Map 3, Fig. 11, Appendix 3). Measurements of D/10 range from 19 to 42 cm. There is no systematic change of the maximum clast size vertically through the section, nor is there any systematic change of D/10. Also there is no consistent change laterally (within any bed) of boulder size. In the field about half the beds appear to have a bimodal grain size distribution, with modes of about 6 and 11 cm. There is no relationship between maximum clast size and lithology.

Internal Structures

The occurrence of the various internal structures is shown in Table 7, at the beginning of this facies description (p. 43). In those beds which display basal inverse grading, the grading is generally

TABLE 7. TYPES OF OCCURRENCE OF THE FACIES
(Coarse Conglomerate, Well Sorted)

Types Of Occurrence Of The Facies	Basal Inverse Grading, Main Part Of The Bed Structureless	Basal Inverse Grading, Main Part Of The Bed Normally Graded	Normal And Inverse Grading At The Base, Main Part Of The Bed Normally Graded	Whole Bed Normally Graded	No Structure At All
Individual Beds Of Coarse Conglomerate	1	2	3	2	2
Coarse Conglomerate Grading To Medium Conglomerate And Coarse Sandstone			1		

Figure 22: Small grain filling the space between larger clasts in the poorly sorted coarse conglomerate facies. The small clast occurs above the six inch mark on the tape.

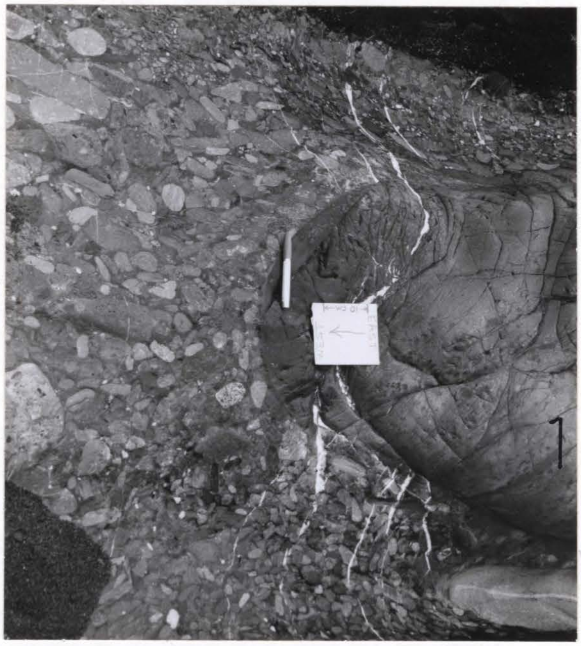


Figure 23: Reversals of imbrication near a large clast in the poorly sorted coarse conglomerate facies. The long axes of the grains dip westward.

confined to within 20 cm of the base. The inversely graded portion is medium conglomerate but pebbles and boulders occur. There is a gradual increase in the percentage of pebbles and boulders upwards. In those beds which display normal and inverse grading, the grading is similar to that shown by the poorly sorted coarse conglomerates. With the exception of those beds which are not graded and the bed which grades into a medium conglomerate and coarse sandstone, the coarse conglomerates have thin developments of medium and fine conglomerates at their tops. Only in one bed (Bed 58) is the fine conglomerate stratified. The stratifications are subparallel and can be traced for 10 m.

The coarsest portion of the facies is never stratified. Linear pebble zones similar to those in the poorly sorted coarse conglomerates are common in this facies.

Composition

The composition of the facies is relatively constant throughout the section (Figs. 14-17, Appendix 4) and is summarized on Table 8.

TABLE 8. SUMMARY OF THE COMPOSITION OF THE FACIES[3] (Coarse Conglomerate, Well Sorted)

Constituent	Range (%) Throughout Section (Bed And Sequence Nos. In Parenthesis)
Sandstone	1(55,3) - 9(35,2)
Quartz	1(55,3) - 8(35,2)
Micrite	26(35,2) - 34(55,3)
Matrix	27(55,3) - 34(35,2)

[3]All those grains with apparent a-axes less than 1 mm were classed as matrix.

The low percentage of matrix suggests the facies is grain supported.

Roundness and Elongation

Two roundness studies, each of one hundred grains, at different localities, give average roundness values of 0.42 (Bed 42) and 0.50 (Bed 23) (Dobkins and Folk, 1970) (Map 3, Appendix 1). These values are higher than that recorded for the poorly sorted conglomerate facies (0.39). Clast roundness ranges from well rounded to angular. The elongation measurements (obtained from two localities) do not show any significant changes vertically within a bed. The average elongation indexes (the averages of the elongation measurements at the two localities) are similar to those measured in the poorly sorted conglomerate, about 2.3 (Map 3, Appendix 2).

Imbrication

Measurements of the easterly dipping imbrication show an increase from the bottom to the top of the section. The increase is from 7 degrees in the first fining upward sequence to 12 degrees in the second to 15 degrees in the third (Beds 9, 35 and 71 respectively, Map 2) (Figs. 19-20, Appendix 5). Generally, the imbricate grains are separated by small grains and matrix (Fig. 25). The small grains (apparent a-axis of 1 cm or less) possess a more random orientation. Near the top of many beds the imbrication dies out and flat lying grains increase in proportion. The flat lying grains are generally less than 3 cm long and are separated by coarse sand and matrix. No reversals of imbrication were recorded in this facies.

Figure 24: Outcrop of well sorted coarse conglomerate.

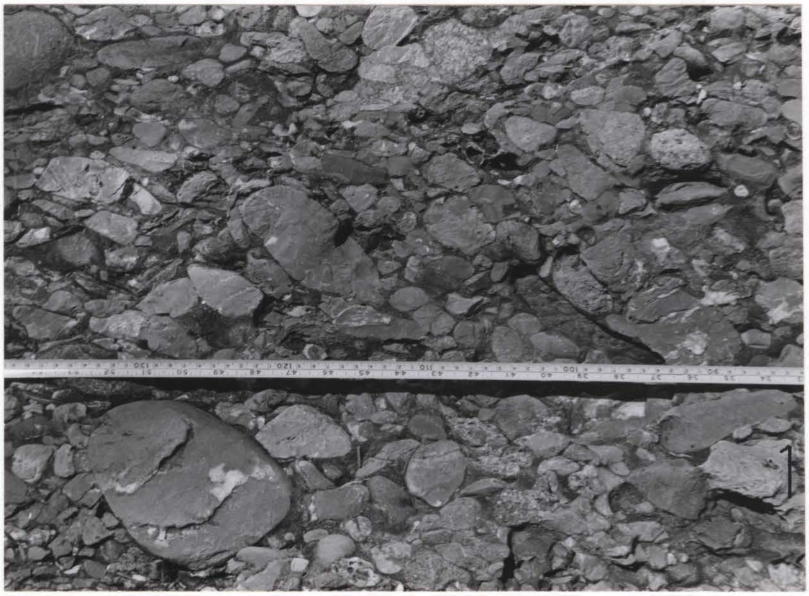


Figure 25: Imbricated well sorted coarse conglomerate. Numbers on the tape decrease eastwards.

Medium Conglomerate with Scattered Pebbles and Boulders

General Features

This facies comprises 45 percent of the sequence (Fig. 26). The types of occurrence of the facies are shown in Table 9.

TABLE 9. TYPES OF OCCURRENCE OF THE FACIES (Medium Conglomerate)

Types Of Occurrences Of The Facies	Whole Bed Stratified	No Structure At All
Individual Beds Of Medium Conglomerate	17	13
Medium Conglomerate Grading To Fine Conglomerate And Coarse Sandstone		1
Medium Conglomerate Grading To Coarse Sandstone	4	1
Medium Conglomerate Graded From Coarse Conglomerates	2	

The average bed thickness is 90 cm with beds ranging from 6 cm to 7 m. Twelve percent of the conglomerates have channelled or scoured bases. The channels are up to 2.5 m wide and 60 cm deep (Map 1) and commonly contain coarse conglomerate material. Twelve percent of the conglomerates have loaded into the sandstones which underlie them. The loads, are generally asymmetric, up to 170 cm long and 25 cm deep. The steeper eastern wall of the loads is sometimes overturned to enclose partially a pocket of conglomerate (Fig. 27). The load structures are developed near to or contain coarse clasts. Seventy percent of the conglomerates have sharp, flat or undulating bases. Individual beds are difficult to trace because of faulting. However, groups of beds up to 2 m thick can be correlated over 300 m. The faices does not display any slump structures. The largest clast (265 cm, Bed 34) is in the second fining upward sequence. The maximum D/10 (63 cm) is also in the second sequence (Bed 34, Fig. 11, Map 3, Appendix 3). The D/10 values do not show any consistent change vertically throughout the section nor laterally within a group of beds. In 20 percent of those conglomerates which are stratified, the coarsest grains are at the base. In 70 percent of the stratified conglomerates the pebbles and boulders are scattered haphazardly throughout. In the remaining 10 percent of the conglomerates the pebbles and boulders increase in size and percentage upwards. The pebbles appear to have a bimodal grain size distribution with modes of 6 cm and 9-11 cm. There is no relationship between clast size and lithology.

Internal Structures

Sixty percent of all the conglomerates are stratified throughout their entire thickness. The stratified conglomerates can be subdivided as follows:

25 percent have low angle stratification

75 percent have subparallel stratification.

The stratifications, which are shown up by the abundance of quartz granules, are up to 50 cm thick (Fig. 28).

Figure 26: Outcrop of Medium Conglomerate with Scattered Pebbles and Boulders.

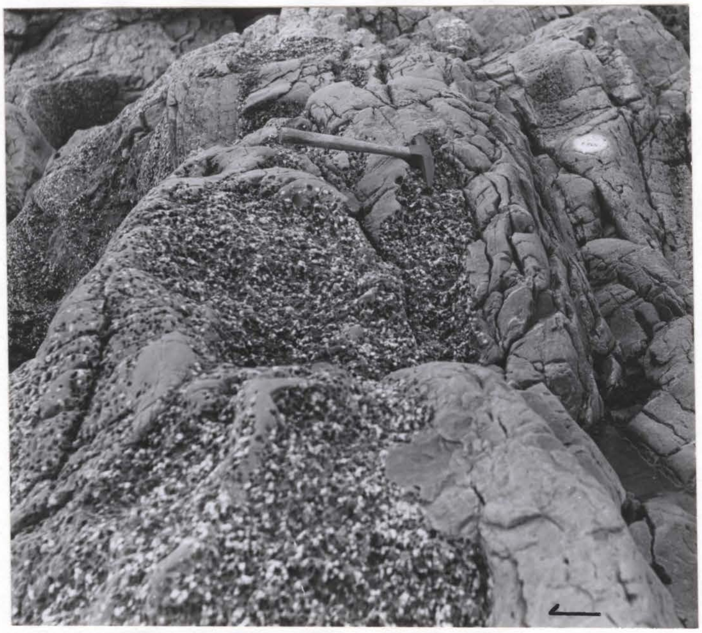


Figure 27: Load structures of Medium Conglomerate with Scattered Pebbles and Boulders in Coarse Sandstone.

Twenty-five percent of the stratified conglomerates have low angle stratification with apparent dips up to 14° west and 14° east. The low angle stratification can occur as a single stratum or in sets up to 50 cm thick. Two types of sets are recognized. In one type the stratifications are straight, parallel and dip either east or west. In the other type the stratifications are concave upwards and dip east and west within the same unit (Fig. 29). Some conglomerates have stratifications which dip south at similar angles. The stratifications can be traced laterally for 10 m

The remaining 75 percent of the stratified conglomerates have subparallel stratifications which can be traced laterally for 15 m

The conglomerates with low angle stratifications are frequently truncated by conglomerates with subparallel stratification. Pebble zones are common (Fig. 13, p. 32).

Alternations of medium conglomerate and coarse sandstone occur at two horizons in the sequence. The sandstones range from 4 to 50 cm thick and have coarse conglomerate clasts up to 14 cm long within them. The sandstones vary in thickness laterally, some become channellized, others are eroded by the overlying conglomerates. One channellized sandstone 20 cm thick thins eastward and its base becomes gradational in that direction. The sandstones cannot be traced laterally for more than 30 m. Most of the sandstones are graded but in each alternation the bottom sandstones are as coarse as those at the top. Coarse grained subparallel layers which average 3 cm in thickness occur in some sandstones. These layers are persistent laterally, some thicken to form medium conglomerates. The sandstones which appear to be bimodal

Figure 28: Stratifications in a medium conglomerate with scattered pebbles and boulders.

Figure 29: Low angle stratifications in a medium conglomerate with scattered pebbles and boulders.

have angular to well rounded grains.

All the unstratified conglomerates grade into thin layers of fine conglomerate which are less than 10 cm thick.

Composition

The composition of the facies is summarized in Table 10, p. 54 (also Figs. 14-17 Map 2, Appendix 4). The low percentage of matrix suggests the facies is grain supported. The pebbles and boulders are similar to those in the coarse conglomerates.

Roundness and Elongation

The average elongation indexes (the averages of the elongation measurements at each locality) range from 2.0 to 2.6 (Appendix 2, Map 3). They do not show any significant change vertically throughout the section. No significant change occurs vertically within any bed.

The average roundness values range from 0.39 (Bed 62) to 0.50 (Bed 51) (Dobkins and Folk, 1970), but no systematic change occurs up section (Map 3, Appendix 1). The grains vary from well rounded to angular (Fig. 30).

Imbrication

Measurements of the easterly dipping imbrication are summarized in Table 11, p. 56 (also Appendix 5, Figs. 19 and 20, Map 4). The imbricate grains are separated by fine conglomerate, coarse sand and matrix (Fig. 31). Within any one bed, imbrication is laterally variable. The variations are summarized in Table 12, p. 56. Bed 36 has two reversals of imbrication, that is, grains with their long axes dipping westward. The angles of imbrication of 1 and 2 degrees (long axes dipping westward)

TABLE 10. SUMMARY OF THE COMPOSITION OF THE FACIES[4]
(Medium Conglomerate)

Constituent	Range (%) Throughout The Section (Bed And Sequence Nos. In Parenthesis)	Range (%) Within The Sequences (Bed And Sequence Nos. In Parenthesis)
Sandstone	3(14,1) - 25(26,2)	3(14,1) - 6(7,1)
		6(49,2) - 25(26,2)
		6(57,3) - 15(65,3)
Quartz	2(65,3) - 40(7,1)	17(14,1) - 40(7,1)
		4(26,2) - 21(23,2)
		2(65,3) - 8(57,3)
Micrite	21(7,1) - 42(51,3)	21(7,1) - 28(14,1)
		26(23,2) - 35(26,2)
		28(52,3) - 42(51,3)
Matrix	12(52,3) - 35(14,1)	24(7,1) - 35(14,1)
		17(26,2) - 31(49,2)
		12(52,3) - 28(57,3)

[4]All those grains with apparent a-axes less than 1 mm were classed as matrix.

Figure 30: Range of roundness in a medium conglomerate with scattered pebbles and boulders.

Figure 31: Imbricated medium conglomerate with scattered pebbles and boulders. The figures on the tape decrease eastwards.

TABLE 11. SUMMARY OF THE IMBRICATION MEASUREMENTS (Medium Conglomerate)

No. Of Grains	Range Of Imbrication In Degrees (Bed And Sequence Nos. In Parenthesis)
100	4(7,1) - 12(38,2)
50 and 25	9(38,2) - 20(4,1)

are recorded at the same outcrop as an angle of 4 degrees (long axes dipping eastward).

TABLE 12. SUMMARY OF WITHIN BED VARIATIONS OF IMBRICATION (Medium Conglomerate)

No. Of Grains	Bed No.	Range Of Imbrication In Degrees (Distance Between Localities Shown In Metres)
50 and 25	26	11-14 (1.0 m)
	4	12-20 (0.75 m)
100	58	8-11 (0.75 m)
	38	7-12 (146 m)

Fine Conglomerate with Scattered Pebbles and Boulders

General Features

This facies comprises about 5 percent of the sequence (Fig. 32). The types of occurrence of the facies are shown in Table 13, p. 58. The average bed thickness is about 90 cm with some beds ranging from 10 to 160 cm (Map 1). Some of the conglomerates are channellized with channels up to 10 cm deep. This facies does not display any slump

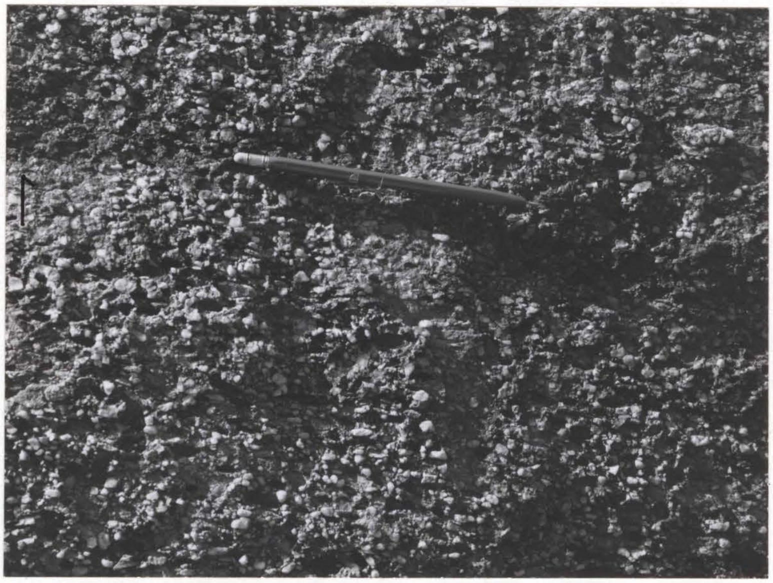


Figure 32: Outcrop of Fine Conglomerate with Scattered Pebbles and Boulders.

Figure 33: Wavy stratifications associated with fine conglomerates and coarse sandstones.

TABLE 13. TYPES OF OCCURRENCE OF FACIES
(Fine Conglomerate)

Types Of Occurrences Of The Facies	Whole Bed Stratified	No Structure At All
Individual Beds Of Fine Conglomerate		1
Fine Conglomerate Grading To Coarse Sandstone	3	3
Fine Conglomerate Graded From Medium Conglomerate	1	

or load structures.

The largest clast (140 cm) and the maximum D/10 (76 cm) are in the fining upward sequence (Bed 16, Map 3, Appendix 3). The coarse conglomerate clasts are scattered throughout the bed. There is no relationship between clast size and clast lithology. The lithologies of the coarse conglomerate clasts are similar to those in the other facies.

Internal Structures

Fifty percent of all the conglomerates are stratified. The stratifications are picked out by increases in the percentage of quartz. Single low angle stratifications with an apparent dip of up to 4° east can be traced for 6 m. Subparallel stratification can be traced laterally for 10 m. Wavy stratifications with amplitude up to 10 cm and wave length up to 1 m can be traced over 10 m. On any one stratification neither the amplitude nor the wave length are constant. The stratifications are up to 30 cm thick (Fig. 33). Pebble zones are common.

At two horizons the conglomerates of this facies alternate rapidly with coarse sandstones which are up to 50 cm thick. Some of the sandstones are eroded by the overlying conglomerates. In alternations 46 and 49 the basal sandstones are coarser than the upper sandstones. Coarse grained layers composed of quartz and feldspar (grains with an apparent a-axis 0.2-0.7 cm long) are common in the sandstones. The layers, which are persistent laterally, are not graded (Fig. 34). The thinnest sandstones (< 5 cm) are developed at the top of wavy and subparallel stratifications (Fig. 33). Clasts of fine conglomerate size in the sandstones generally have an orientation subparallel to bedding. The sandstones, which appear bimodal, have well rounded to angular grains.

Composition

The composition of one bed (Bed 18, Map 2) in the first fining upward sequence is summarized in Table 14 (Appendix 4).

TABLE 14. SUMMARY OF THE COMPOSITION OF BED 18[5]

Constituent	Percentage
Sandstone	1
Quartz	30
Micrite	21
Matrix	41

[5]All those grains with apparent a-axes less than 1 mm were classed a matrix.

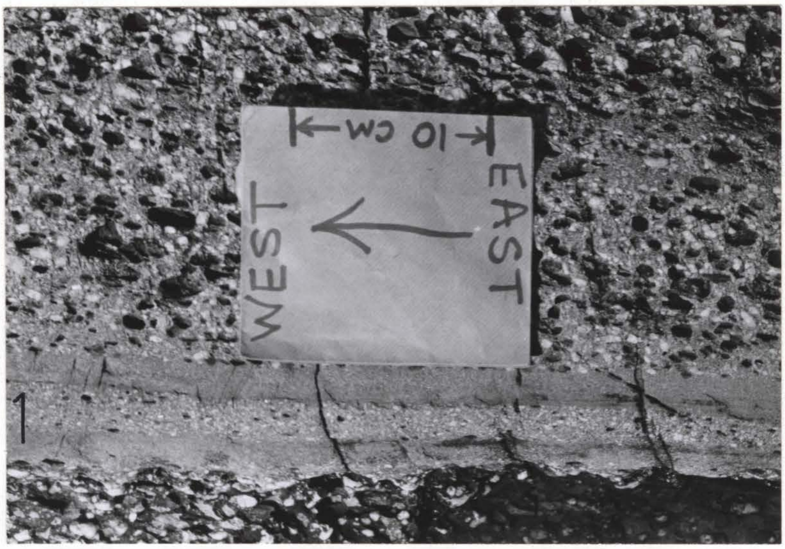


Figure 34: Coarse grained layers in the sandstones associated with the fine conglomerates.

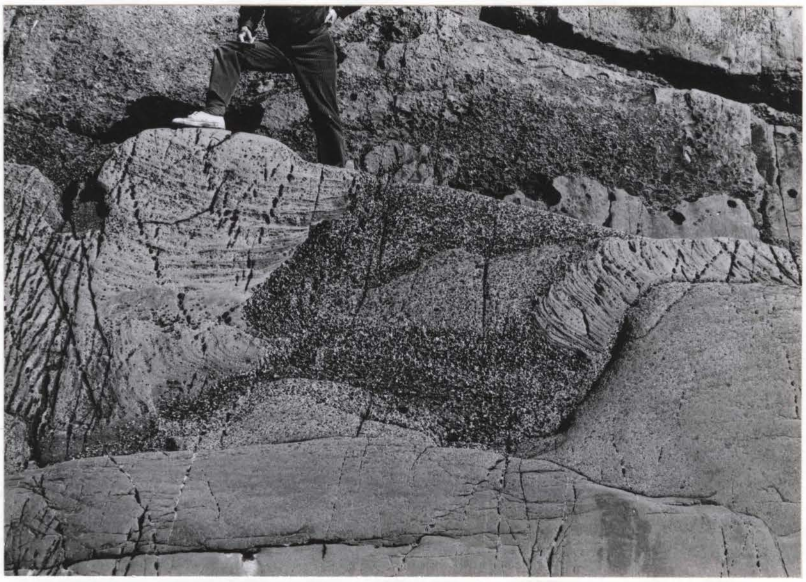


Figure 35: Trough cross-stratification in a fine conglomerate with scattered pebbles and boulders.

Elongation, Imbrication and Roundness

The average elongation index for one bed is 2.4 (Map 3). The elongation ranges from 1.00 to 6.5 (Appendix 2) but no consistent change occurs vertically. Imbrication is not developed but grains subparallel to the stratification are common. The grains are separated by coarse sand and matrix. The grains are well rounded to angular.

Palaeocurrent Measurements

Two measurements of trough cross-stratification (Bed 50, Map 1, Fig. 35) give palaeocurrent directions of 163 and 193 degrees. These directions compare favourably with those presented by Mathey (1970) but differ considerably from the palaeocurrent directions based on grain orientations presented in this study.

Coarse Sandstones

General Features

This facies comprises about 18 percent of the sequence. The types of occurrence of the facies are shown in Table 15. The average bed

TABLE 15. TYPES OF OCCURRENCE OF FACIES
(Coarse Sandstones)

Coarse Sandstones With Sharp Bases	6
Coarse Sandstones Which Grade Up Rapidly From Conglomerates	10
Coarse Sandstones Which Grade Up Gradually From Conglomerates	7

thickness is about 60 cm, with some beds ranging from 10 to 160 cm. At the base of those sandstones which grade up rapidly from the conglomerates below, there is a transitional zone, marked by a coarse sandstone with clasts of fine conglomerate size. The transitional zone is 3-4 cm thick. Those sandstones which grade up gradually from the conglomerates have similar transitional zones, up to 25 cm thick. In 50 percent of the sandstones isolated clasts of fine conglomerate size occur up to 10 cm above the transitional zones. The sandstones with sharp bases have channels or scours up to 60 cm deep (Bed 27). In some places, injected dikes of sandstone penetrate upward into the overlying conglomerate for distances up to 130 cm. They occur near coarse conglomerate clasts. The texture of the overlying conglomerate is disrupted near the injection structure (Fig. 36). Pebbles and boulders, up to 36 cm long, occur rarely in this facies. In places boulders are associated with load structures which occur nearby. In other cases, the pebbles and boulders rest in the centre of the sandstones and in the overlying conglomerate there is a complete absence of boulders.

In the first and second fining upward sequences the sandstones are eroded by the overlying conglomerates. The sandstones are difficult to trace because of faulting. In the third sequence the sandstones are traced without difficulty.

Internal Structures

Twenty-five percent of the sandstones display dish structure (Fig. 37). The structure occurs in zones up to 45 cm thick, some of which are diffuse but others are sharp and can be traced for 5-6 m laterally. The dishes are up to 10 cm wide and 1 cm deep. The form of the dish structure appeared to remain relatively constant when the zones

Figure 36: Disrupted conglomerate texture near a sandstone injection structure.

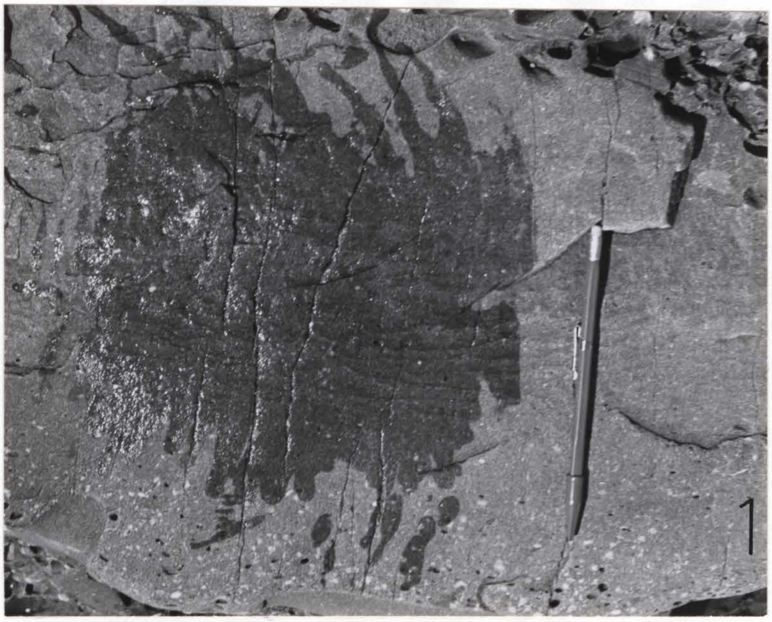


Figure 37: Dish structure in coarse sandstone.

were traced laterally and vertically. The structure occurs below subparallel laminations. Sixty percent of the sandstones have subparallel lamination (lamination < 2 mm thick) in zones up to 45 cm thick which can be traced laterally for up to 15 m. Generally the zones extend to the top of the bed but in some cases the subparallel lamination disappears near the top.

Fifty percent of the sandstones exhibit low angle lamination. The laminations, which are less than 5 mm thick, have an average apparent dip of 8 degrees west and single sets (generally less than 10 cm thick) can be traced laterally for 6 m. The tops of the laminations are always truncated, either by the overlying conglomerate or by subparallel lamination. In some beds the low angle lamination overlies the subparallel lamination.

Twenty-five percent of the sandstones display trough cross-bedding, but only one bed gives a reliable palaeocurrent direction. This indicates a current flowing from the northwest (240°). The cross-bedding, which occurs in single sets up to 1 m wide and 30 cm thick, has an average apparent dip of 20 degrees, and the tops of the sets are generally truncated. Within some sets the apparent angle of dip decreases upwards until it becomes subparallel. The trough cross-bedding is frequently coarser grained than the material below it.

None of the sandstones display convolute lamination, but zones of coarse grained lamination (laminations > 2 mm but less than 1 cm thick) occur in 90 percent of the beds. The laminations, which do not appear to be graded, are composed of quartz and feldspars (grains with an apparent a-axis 0.1 cm-0.5 cm). The laminations have sharp bases and tops. The zones, which are often associated with amalgamated beds, are up to 20 cm thick and can be traced laterally for 5 m. In the second fining upward sequence two sandstone beds amalgamate eastwards (Fig. 38). Fine conglomerate grains are scattered above the junction of the two beds.

Composition

The composition of the sandstones does not vary a great deal (Fig. 39, Appendix 4). The compositions presented here compare well with those presented by Mathey (Fig. 40) (Mathey, 1970). The most common constituents are quartz and feldspar. The feldspars include orthoclase, perthite, microcline and plagioclase. Extremely small percentages of biotite, muscovite, sedimentary rock fragments, zircon and apatite are present. The grains range from well rounded to angular. The matrix is chloritic and very fine quartz and the cements are silica and calcite.

Figure 38: Truncated fine conglomerate which fills a scour in a coarse sandstone.

Figure 39: Composition of the Coarse Sandstones. (Classification after Williams et al., 1954.).

Figure 40: Composition of the Coarse Sandstones. (From Mathey, 1970. Classification after Williams et al., 1954.).

Figure 39

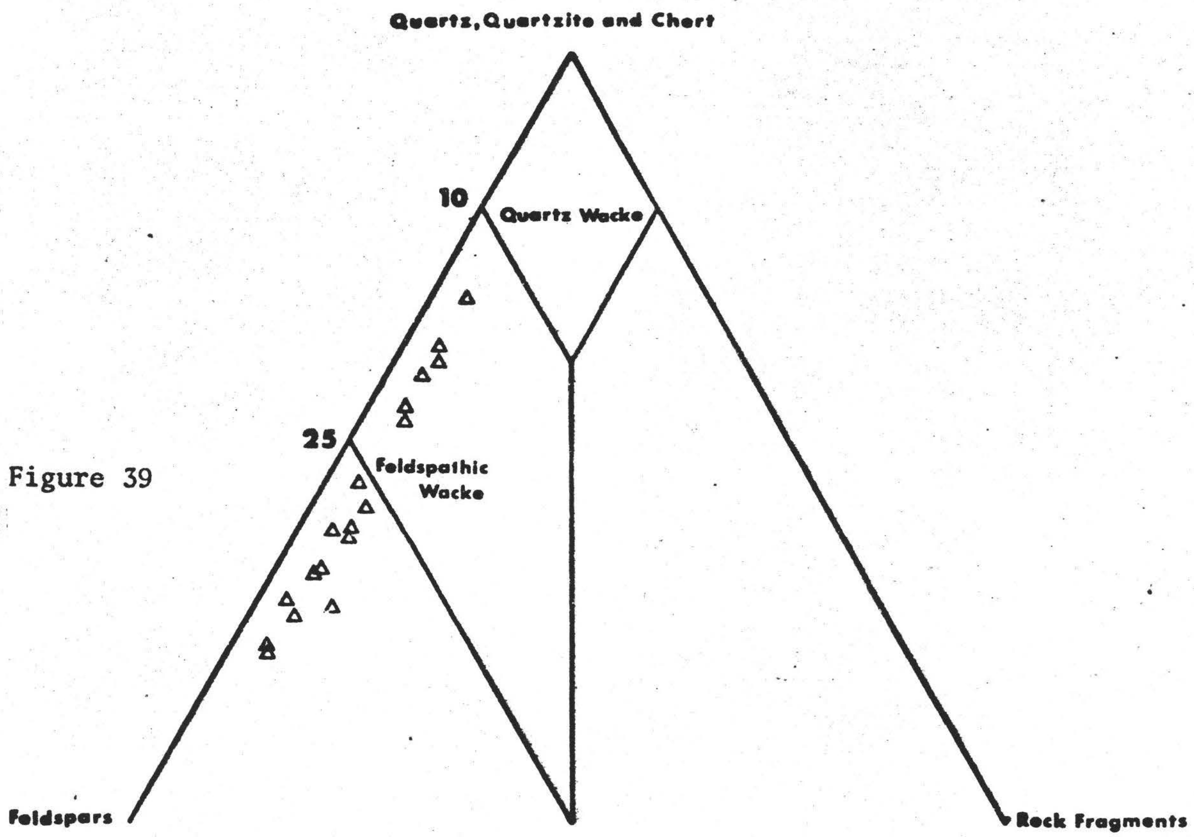
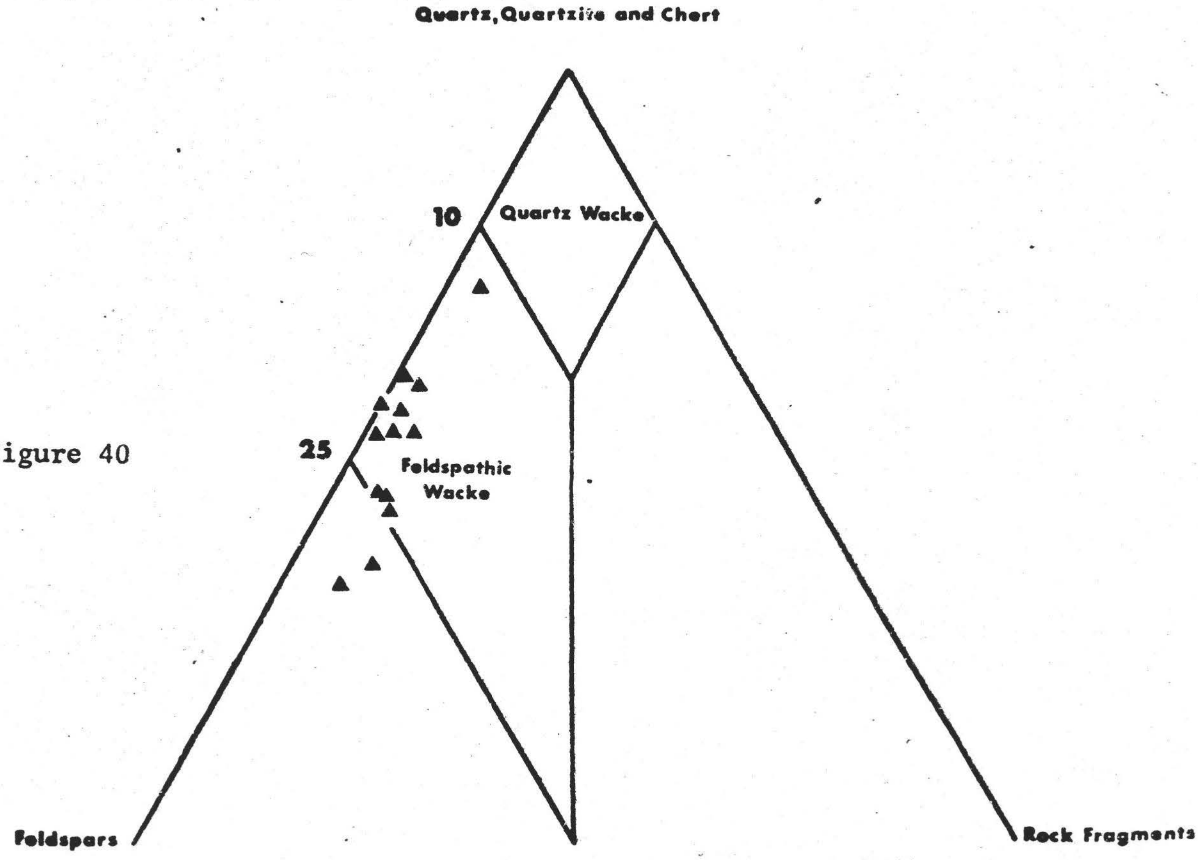


Figure 40



Orientations

It was necessary to compare any palaeocurrent data with that which had been previously collected in the area. The restriction of the measurement of grains greater than 3 cm long was not applied to the orientation study because on the bases of the beds studied most of the grains (over 80 percent) were longer than 3 cm and on the tops most were shorter than 3 cm

The grand vector mean calculated from 6897 vectors was 236 degrees (standard deviation 15 degrees) (Appendix 6). Sixty-nine vector means were calculated and they varied from 220 degrees (Bed 23) to 256 degrees (Bed 29). Fourty-one of the vector means were measured on the tops of beds, twenty were measured on bases and eight were measured at different horizons within certain beds (Map 4). The grain orientation information is summarized in Table 16, p. 69. The four vector means which differ from the grand vector mean by more than one standard deviation are shown on Table 17, p. 70.

No appreciable change in the vector means appears to occur vertically throughout the section or laterally within a single bed. The variation of the vector means in each sequence is summarized in Table 18, p. 70. Lateral differences in orientation (within a single bed) appear to be random. They are summarized in Table 19, p. 71. Mathey (1970) observed nine palaeocurrent indicators in Horizon 3, which are shown in Table 20, p. 72 (see also Table 2). These palaeocurrent directions differ significantly from the preferred grain orientations presented here. The strike of the rocks in Horizon 3 is 233 degrees and this differs by only 3 degrees from the grand vector mean of 236 degrees. The palaeocurrent

TABLE 16. COMPARISON OF VECTOR MEANS WITH GRAND VECTOR MEAN

Facies	Number Of Vector Means Which Differ From The Grand Vector Mean < 1 Standard Deviation	Number Of Vector Means Which Differ From The Grand Vector Mean > 1 Standard Deviation
Coarse Conglomerate Poorly Sorted	2	2
Coarse Conglomerate Well Sorted	10	1
Medium Conglomerate With Scattered Pebbles And Boulders	48	1
Fine Conglomerate With Scattered Pebbles And Boulders	5	

TABLE 17. VECTOR MEANS WHICH DIFFER FROM GRAND VECTOR MEAN BY MORE THAN ONE STANDARD DEVIATION

Bed Number	Facies	Position In Bed	Vector Mean
23	Coarse Conglomerate, Well Sorted	Bottom	220
28	Coarse Conglomerate, Poorly Sorted	Within Bed	253
29	Coarse Conglomerate, Poorly Sorted	Within Bed	256
49	Medium Conglomerate With Scattered Pebbles And Boulders	Top	252

directions given by Mathey (1970) are approximately transverse to the strike. The imbrication studies show a consistent easterly inclination

TABLE 18. VARIATION OF VECTOR MEANS IN EACH SEQUENCE

Sequence Number	Range (Degrees) Of Vector Means (Bed Number In Parenthesis)
1	230(21) - 244(16)
2	220(23) - 256(29)
3	221(61) - 247(72)

of elongate grains. This inclination and the grand vector mean of 236 degrees are interpreted as indicating currents flowing toward the

TABLE 19. VARIATION OF VECTOR MEANS WITHIN BEDS

Bed Number (Sequence In Parenthesis)	Range (Degrees) Of Vector Mean	Position In Bed	Distance In Metres Between Vector Means
21(2)	230 - 235	Top	2.0
49(2)	233 - 252	Top	3.5
23(2)	220 - 223	Bottom	1.0
42(2)	223 - 238	Bottom	18.0

TABLE 20. PALAEOCURRENT MEASUREMENTS FOR HORIZON 3

Current Direction And Sense Known		Current Direction Known	
Cross-Stratification	Channels	Channels	
200		160	125
185	180	150	020
		150	015

southwest parallel with the present day tectonic axes.

CHAPTER 4

INTERPRETATION

The interpretation of the conglomerate sandstone sequence at St. Simon can be approached by accounting for the most prominent and problematic features of the deposit. The most important features are; the facies distribution, the normal and inverse grading, the imbrication and orientation, and the stratification. Other features include, the range of roundness and elongation, the range of the D/10 values and the occurrence of the thick massive sandstones.

Facies Distribution

Figures 4-7 show that there are few gradational contacts between the facies. Coarse conglomerates generally occur as beds of coarse conglomerate, and do not pass up into thick developments of medium and fine conglomerates. This feature may be related 1, to the grain size distribution of the sediment which was available for deposition; 2, to the mechanism of deposition; or 3, to erosion which occurred after deposition. The occurrence of channels indicates that some erosion occurred after the deposition of the conglomerates. However, it seems unlikely that erosion would result in the consistent development of only 10-15 cm of fine conglomerate at the top of most coarse conglomerate beds. Also, if a thin development of fine conglomerate were formed at the top of a bed, it is difficult to envisage the depositing flow not forming thicker layers of fine conglomerate if fine conglomerate were available. Thick gradational sequences between the facies are absent because there was a lack of certain grain sizes in the original grain size distribution available for deposition.

Normal and Inverse Grading

The types of grading have been outlined in the facies description. Some of the normal grading in the conglomerates is shown up by a decrease of the maximum grain size upwards through the bed. This type of grading has been called "coarse-tail grading" by Middleton (1967) and he described it (Middleton, 1962) in turbidites of the Ordovician Normanskill and Charny Formations. Middleton (1967) produced the coarse-tail grading in experimental studies on high concentration turbidity currents (approximately 40 percent by volume). Other features of the conglomerates also suggest that the depositing flows were of high concentration. Inverse grading is common in the conglomerate facies. The inverse grading is confined to the bases of the beds. Above the zone of inverse grading, normal grading occurs. Bagnold (1954) suggests that the transfer of momentum, from grain to grain within a high concentration flow, supports the grains throughout the flow. Bagnold suggests that the dispersive force acting upon a particle is proportional to the rate of shear acting on the flow. For the flows which deposited the conglomerates at St. Simon, shear could have been the result of downslope movement of material under the influence of gravity. At the top of a flow, interaction with the overlying fluid medium and an increase in the dispersive pressure might have initiated turbulence. Continued downslope flow could have resulted in the turbulence spreading down through the flow. Normal grading would result from the settling out of the grains from the turbulent flow. Consequently, those beds which do not display any grading are probably the result of those flows which did not become turbulent.

If the turbulence did not extend throughout the flow, the basal section of the flow would be influenced by the dispersive pressure existing there. If the dispersive pressure were sufficiently high, grains would have moved with some degree of independence. Middleton (1970) has suggested that inverse grading develops because "the smaller particles tend to fall into the spaces between the larger particles and thus displace the larger particles toward the surface". Such a mechanism would operate in a flow where the dispersive pressure allowed some independent movement of the grains, producing inverse grading. The imbrication and orientation also suggest that dispersive pressures operated when the conglomerates were formed.

Those beds which display inverse and normal grading and those beds with inversely graded areas containing boulders, suggest that turbulent conditions existed at some stage in the flow. A change in the flow, from turbulent conditions to conditions in which dispersive pressures were important would account for the formation of inverse grading (by using Middleton's idea that the smaller particles displace the larger particles towards the surface). The time period over which the dispersive pressure operated must have been a short one because the inverse grading does not extend throughout the bed. Middleton (1967) suggests that a decrease in the shear stress in a flow will result in an increase in the viscosity. In the flows which deposited the conglomerates at

St. Simon a decrease in the shear stress would have been the result of the end of downslope movement of the material under the influence of gravity. A rapidly progressive increase in the viscosity upwards from the base would have resulted in the preservation of the grading within the bed. Rapid conditions of deposition and consolidation must be invoked to preserve the grading displayed in the conglomerates.

Imbrication

Some clues for the interpretation of these deposits are also offered by the imbrication. All the facies show imbrication, some to a greater extent than others. Imbrication can be the result of several processes. It has been observed in streams and flumes (Fahnestock and Haushild, 1962) that deposition of a pebble on a sand bed will result in erosion upstream of the pebble, so that the pebble will fall into the scour pocket created. However, this process will not account for the imbrication observed in the conglomerates because not all the conglomerates lie upon sand beds.

Pebbles moved as bed load material in flows become imbricated when they come to rest behind a stationary pebble (Johansson, 1963). The preferred orientation of the long axes is statistically perpendicular to the direction of the flow (Rust, 1972). In the present study the long axes were found to be parallel to, and not transverse to the flow direction suggested by the imbrication. A unimodal distribution of long axes occurs and hence it is unlikely that the pebbles rolled as bed load material.

It has been suggested that dispersive pressures operated during the formation of the conglomerates. Under these conditions most of the grains will not be in contact with the base of the bed, that is, they will not move as bed load material. Experimental studies on the movement of coarse material in suspension are hindered by the scale of the experiment required. However, some theoretical considerations of the movement of ellipsoidal particles in suspension have been made. Jeffery (1922) considered the movement of ellipsoidal particles in a viscous fluid. He showed that, provided the velocity of the flow were small, the ellipsoids were carried forward rotating in orbits about their centres (Fig. 41).

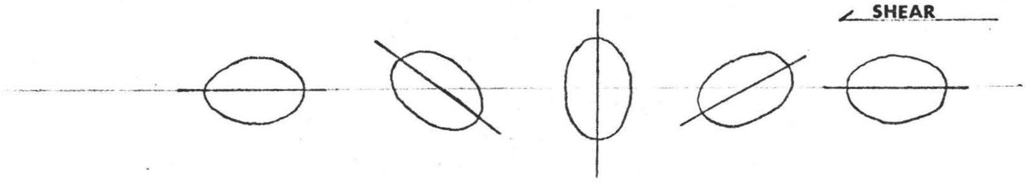


Figure 41. The movement and rotation of an ellipsoidal particle in a shearing medium. (Modified from Glen, Donner and West, 1953).

The rate of rotation varied with the position of the long axes of the pebbles, being at a minimum when the long axes of the pebbles were nearly parallel to the direction of flow. By adopting Jeffery's theory for the rotation of ellipsoids in a plane parallel to the flow, we can account for the imbrication displayed by the conglomerates. Jeffery's theoretical considerations have been supplemented by Taylor (1923). Taylor found that ellipsoids in a viscous fluid under shear tended to assume a transverse position in the flow only if the particles had been in the flow for a long time. Few transverse orientations are recorded in the conglomerate deposits. This might indicate that the time period during which the imbrication and orientation developed was a short one.

Glen, Donner and West (1953) use Jeffery's theory and consider the effect of collision between the particles in the flow. They suggest that, "Collisions may aid the stones to move from orbit to orbit towards the orbit of minimum energy, and in this way could favour the transverse orientation". Manley, Arlov and Mason (1955) also suggest that a high concentration of particles in the flow will lead to the development of a transverse orientation. This transverse orientation would not be compatible with the parallel orientation associated with the imbrication in this study.

Bagnold's theory for the dispersive pressures operating in high concentration flows has been considered for the formation of the inverse grading. Rees (1968) utilizes Bagnold's theory and considers the movement of ellipsoids being sheared in a fluid. He considers the movement of particles in layers, with collisions occurring between particles in adjacent layers and suggests (Rees, 1968) that, "If the collisions are elastic the force in each will be perpendicular to the tangent plane common to the two colliding particles." (Fig. 42).

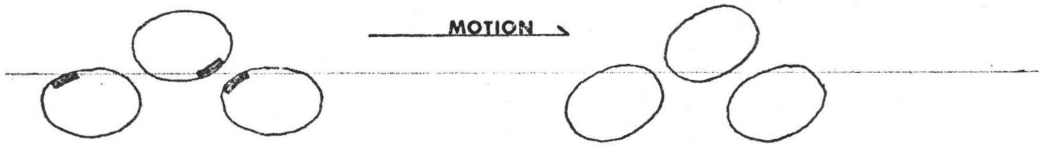


Figure 42. Collisions between particles in layers with fractional overlap. (Modified from Rees, 1968).

In this way a tilt of the long axes of the particles occurs. This tilt can be interpreted as imbrication. Rees favours collisions which result in the long axes of the particles being parallel to the flow, as in the present study. Thus the imbrication seen in the conglomerates could be produced at a late stage in deposition when dispersive pressures are more important than turbulent conditions of flow.

If dispersive pressures were sufficiently high in a flow, it is not unlikely that the grains would be free to rotate during transportation. It is possible that the movement of the grains would be similar to the movement outlined by Jeffery (1923). Lindsay (1968), utilizing Jeffery's theory, demonstrated by computer simulation that strong long axis fabrics may develop in high concentration flows in a short period of time. In any one situation, the rate at which the fabric develops depends upon the viscosity. The development of the fabric is cyclical. Initially the clasts are in a random orientation. The clasts become oriented with their long axes parallel to the direction of flow and dipping steeply upstream. The angle of plunge of the long axes decreases as the fabric develops. Maximum development of the fabric occurs when the long axes are horizontal and parallel to the direction of the flow. The fabric begins to degenerate when the long axes dip downstream. The strength of a fabric within a flow is related to the time at which the cycle of development is stopped. The cyclical development of the fabric can account for the orientation, imbrication and the reversals of imbrication recorded in the facies.

It was noted that the imbrication died out at the top of many beds. According to Lindsay (1968) this might represent the maximum of the cycle of development of the fabric. However, if the turbulent conditions which resulted in the formation of grading ceased rapidly and the shearing which produced the imbrication and orientation decreased in intensity upwards through the bed, little imbrication would form at the top of the bed. To preserve the imbrication rapid consolidation of the bed is necessary as has been suggested for the grading.

Channels and Stratification

Most beds have plane to undulating bases but a few are channellized. The plane and undulating bases are probably a function of the fact that the direction of strike and the presumed palaeocurrent direction are the same, hence cross sections of channels would tend not to be exposed. Those beds which exhibit channelling were deposited by currents which did not flow parallel to the present tectonic axes. Some of the medium conglomerates exhibit arcuate stratifications which dip east, west and south. These stratifications are the result of the infilling of scours excavated by currents which flowed in different directions.

Subparallel and low angle stratifications with apparent dip up to 14 degrees occur in some conglomerates. The low angle stratification (p. 49) occurs either as a single stratum or in sets. The stratifications are graded, the finest material occurring at the top. The flows which deposited the stratifications must have been turbulent because many stratifications are normally graded.

Range of Roundness and Elongation

The roundness values range from .38 to .50. The value of .38

corresponds to the mean value of roundness of pebbles collected from streams on Tahiti-Nui, the value .50 is close to the mean value of roundness of those pebbles collected upon beaches on Tahiti-Nui (.55) (Dobkins and Folk, 1970). However, the limitations of using this method for consolidated samples may introduce a significant error in the roundness value of a pebble. This method is of more use on outcrops where the pebbles can be removed intact from the rock.

No consistent vertical change of elongation was noted within the beds studied. This suggests that the flows were not capable of effecting any sorting of the grains according to their elongation. Middleton (1962) also noted that currents which deposited Normanskill and Charny sandstones did not effect a strong shape-sorting. The conglomerates are poorly sorted and this suggests that deposition may have been rapid.

Range of the D/10

No appreciable change of the D/10 was noted throughout the sequence. Because of the outcrop length, it is difficult to make any comment as to whether the competency of the flows decreased in the presumed downcurrent direction. Perhaps later studies carried out over a wider area will show a systematic change of the D/10.

One large isolated boulder in Bed 16B (Map 1) gives some idea of the mechanism of transportation. This boulder has a crack down to its centre which is filled with coarse sand, identical to that in the bed above. The sides of the crack are lined with a laminated layer of calcite about one inch thick. It is most probable that this laminated calcite existed in the boulder before it was transported by the current.

During transportation and deposition intergranular collisions and collisions with the substratum were sufficient to crack the boulder along the calcite layer but not to break the boulder. The boulder came to rest with the crack opening upward, and the crack was filled with sand during deposition of the next bed.

Slumping

There is no sign of slumping within the entire section, and transportation of the beds by "slumping" is unlikely. There is evidence, indicated by the occurrence of load structures, that the sediments were capable of moving under the influence of loading. The load and associated injection structures are not widespread, but are restricted to the top part of each fining upward sequence and always associated with coarse conglomerate.

Composition of the Conglomerates

The increase in the percentage of quartz upwards through the sequence has been noted by Mathey (1970) at St. Simon and by Hubert et al. (1970) at St. Fabien. Hubert et al. (1970) suggest, "In order to provide an increase in quartz, new sources had to become available".

Coarse Sandstones

The coarse sandstones are associated with the conglomerate in three ways. They either grade gradually or rapidly from the conglomerates or they fill channels cut into the conglomerates. There are some sandstones which in parts are channellized but when they are traced laterally they are seen to grade up from conglomerates. This suggests that the depositing flow was behaving differently at various points, depositing in some areas but eroding in others.

Stauffer (1967) describes sandstones which he believes were formed by flows in which grain interactions were controlling the flow. The sandstones described are similar in many respects to those studied herein. Both types contain outsized clasts, and are poorly graded with relatively sharp bases. They are massive but do exhibit subparallel lamination and dish structure. The sandstones lack such features as flutes, grooves and ripple-drift cross-lamination. Bagnold's theory (1954) of dispersive pressures can be utilized to explain the features of the sandstones. Under the influence of dispersive pressure features such as ripple-drift cross-lamination and parallel lamination would not form. However, if the flow had previously been in a turbulent condition, as is suggested by the grading and imbrication of the conglomerates, some parallel lamination could have formed when the flow was decelerating.

Large scale cross-stratification occurs at the tops of some sandstones. Middleton (1969) has suggested that the cross-stratification may be the result of deposition in scours formed by the entrained fluid along the top of the flow. The subparallel lamination seen near the top of some coarse sandstones may also be formed by this mechanism. However, some sandstones are obviously amalgamated (Fig. 38) and the coarse grained laminations seen in some sandstones may be the result of several amalgamations.

Evolution of the Flow

To understand the evolution of the flows which produced the conglomerate and sandstone sequence at St. Simon, we must account for the mechanisms which have been invoked to explain the sedimentary structures within the deposits. We must account for the turbulence and dispersive pressures, but this problem is difficult to resolve because experimental work on coarse grain deposits and observations of natural processes involving coarse grained deposits are few. Morgenstern (1967) has given some theoretical consideration to the problem of the development of turbulence within flows. He suggests that excess pore pressures must exist in a cohesionless mass moving downslope before turbulence will be initiated in the mass. The method by which excess pore pressures build up in coarse grain deposits is not clearly understood. Morgenstern (1967) suggests that dissipation of excess pore pressure and a rapid decrease in the slope over which the mass flows would prevent the onset of turbulence. Mixing of the sediment on the surface of the flow with the overlying fluid medium is also important because it relates to the density of the flow. The mixing process must be clarified before the mechanics of high density turbulent flows can be explained.

In the light of our present knowledge, the evolution of the flows which deposited the conglomerate sandstone sequence at St. Simon is envisaged in four stages.

(1) Initial downslope movement of a sediment under conditions of excess pore pressures.

(2) Continued downslope movement under conditions of excess pore pressure initiates turbulence at the top of the flow. Continued movement under turbulent conditions produces normal grading vertically and laterally within the flow.

(3) As material settles to the base of the flow, dispersive pressures are established and inverse grading, imbrication and orientation are formed.

(4) Rapid freezing results in the preservation of the internal structures.

Depositional Environment and Palaeogeography

At the present time deep water conglomerate deposits are restricted to submarine fans and submarine channels. It is likely that these environments existed in the past and were major areas of accumulation of conglomerate deposits. For the Québec Group deposition of conglomerates on submarine fans has been suggested by Mathey (1970) at St. Simon and Hubert et al. (1970) St. Fabien and L'Islet. For the St. Simon area, Mathey (1970) envisages a submarine fan complex, built of sandy and conglomeratic material by turbidity currents and slumps (glissements) which flowed transverse to the present tectonic axes. The currents and slumps reached the sea floor by way of a submarine canyon which extended into a shelf sea area.

For the St. Fabien and L'Islet areas, Hubert et al. (1970) propose a similar model to the one suggested by Mathey (1970). "An unstable source area composed of shelf type limestones and sandstones and the Precambrian Shield area provided coarse debris which were channellized and deposited on submarine fans by turbidity currents and other mechanisms.". Hubert et al. (1970) indicate that currents which flowed parallel to and transverse to the present tectonic axes were operative during the formation of the submarine fan complex.

Figure 43: Reconstruction of the Cambro-Ordovician palaeogeography in the St. Simon area. The sediments are derived from Palaeozoic limestones (blocks) and sandstones (stippling), and Precambrian metamorphic (folded) and igneous (cross) terranes. (Modified from Hubert et al., 1970.).

For the outcrop at St. Simon it is suggested that the conglomerate and sandstone sequence studied exists on that part of the submarine fan complex which was built by currents which flowed mainly parallel to the present tectonic axes (Fig. 43). However the problem to be explained

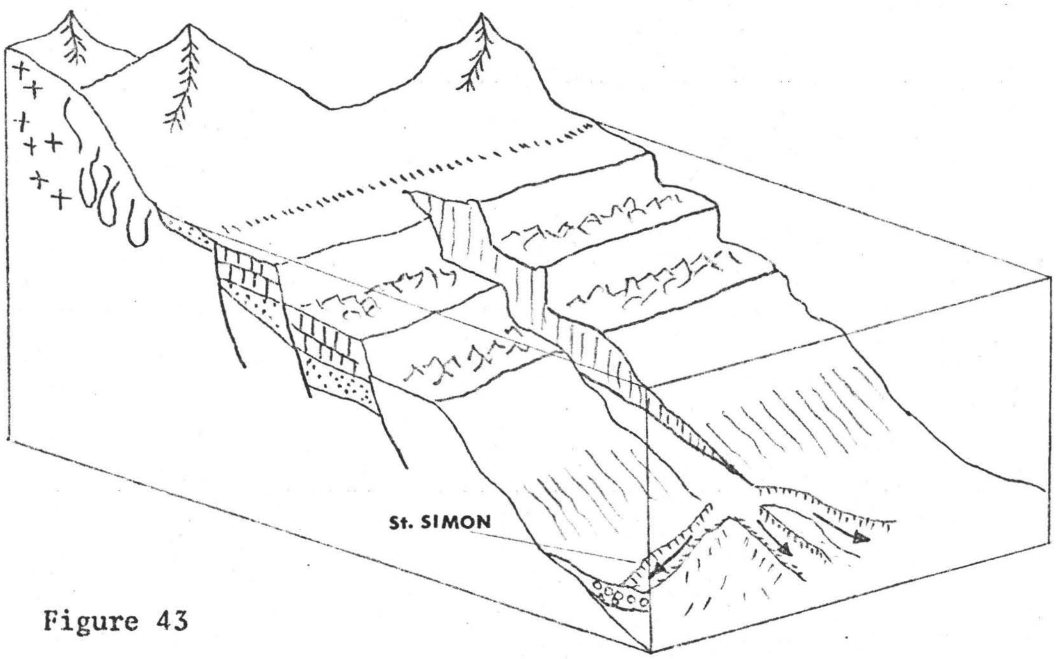


Figure 43

is why the sequence was deposited parallel to the present tectonic axes. The currents might have flowed along a meandering channel which is parallel to the present tectonic axes or they might have flowed in a distributary channel which is parallel to the present tectonic axes. Both types of channels have been reported on the La Jolla Fan Complex off the coast of California (Normark, 1970). However, the length of the outcrop studied does not enable the distinction between the two channel types to be made.

An alternative theory is that the conglomerates occupy a submarine channel beyond the margins of the fan. A present-day example of such an environment is the Cascadia Channel. The channel runs for about 200 km parallel to the present tectonic axes along the coast of Oregon (Griggs and Kulm, 1970). However, an environment similar to the Cascadia Channel would not fit the stratigraphical evidence which has been recorded in the St. Fabien and St. Simon areas. It would not account for the palaeocurrent data recorded by Mathey (1970) in Horizon 3 (Table 20), which indicate that some currents flowed from the north and northwest. Also, it would not account for the lenticular shape of Horizon 3 nor for the thinning of Horizon 3 towards the southeast (Mathey, 1970), that is, in the direction transverse to the present tectonic axes.

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APPENDIX 1

ROUNDNESS MEASUREMENTS

(1)				
.58	.25	.22	.33	.29
.33	.19	.21	.25	.33
.67	.33	.38	.20	.50
.56	.40	.56	.57	.57
.60	.30	.40	.53	.40
.25	.63	.25	.33	.38
.25	.33	.17	.83	.40
.23	.67	.25	.50	.38
.43	.29	.50	.38	.23
.40	.59	.40	.33	.38
.10	.30	.38	.25	.50
.33	.33	.25	.57	.50
.21	.50	.44	.67	.33
.38	.40	.30	.60	.67
.43	.57	.40	.17	.42
.29	.33	.25	.13	.70
.38	.25	.50	.50	.67
.50	.38	.13	.50	.29
.38	.40	.50	.30	.50
.67	.33	.50	.33	.33

(2)				
.38	.50	.40	.50	.75
.36	.33	.67	.67	.50
.43	.67	.60	.50	.50
.43	.33	.50	.25	.50
.50	.43	.50	.25	.50
.38	.50	.50	.25	.67
.20	.30	.25	.38	.75
.40	.38	.50	.25	.75
.15	.25	.50	.50	.33
.25	.43	.67	.50	.50
.75	.17	.38	.25	.67
.33	.50	.25	.50	.50
.30	.38	.75	.50	.50
.38	.53	.50	.67	1.00
.33	.43	.38	.40	.75
.40	.50	.67	.50	.40
.75	.50	.50	.50	.38
.50	.24	.67	.67	.50
.60	.38	.67	.50	.33
.67	.71	.40	.50	.50

(3)				
.33	.50	.38	.25	.50
.21	.17	.50	.50	.33
.25	.50	.40	.50	.50
.40	.40	.17	.50	.50
.20	.17	.17	.33	.75
.25	.43	.38	.40	.50
.25	.67	.33	.33	.43
.25	.17	.14	.67	.75
.33	.14	.14	.67	.60
.33	.33	.17	.25	.40
.48	.20	.38	.33	.50
.19	.50	.33	.50	.20
.25	.25	.50	.33	.60
.50	.17	.33	.67	.25
.40	.50	.75	.50	.25
.75	.25	.50	.25	.25
.20	.30	.50	.50	.50
.33	.39	.33	.50	.25
.17	.33	.17	.33	.20
.25	.75	.67	.25	.38

(7)				
.57	.19	.43	.70	.57
.57	.43	.27	.50	.33
.53	.50	.40	.33	.75
.56	.38	.40	.29	.60
.67	.50	.50	.25	.40
.50	.50	.50	.33	.33
.43	.43	.43	.50	.30
.76	.63	.33	.33	.29
.42	.33	.50	.50	.17
.50	.29	.80	.60	.10
.30	.19	.43	.17	.21
.50	.75	.50	.44	.50
.33	.44	.17	.50	.33
.38	.38	.75	.33	.25
.33	.25	.50	.21	.55
.42	.40	.38	.50	.40
.80	.13	.40	.71	.33
.50	.29	.29	.33	.40
.26	.42	.38	.40	.14
.38	.17	.29	.50	.67

(8)				
.33	.67	.50	.38	.50
.17	.20	.75	.30	.50
.33	.75	.67	.50	.33
.60	.13	.38	.50	.50
.40	.25	.40	.40	.33
.13	.63	.50	.33	.50
.25	.19	.80	.33	.50
.50	.33	.33	.75	.50
.17	.20	.50	.20	.50
.21	.50	.33	.33	.50
.23	.25	.25	.50	.50
.25	.17	.33	.50	.67
.25	.17	.50	.60	.50
.22	.25	.33	.50	.50
.30	.22	.50	.25	.75
.25	.38	.33	.75	.75
.21	.38	.17	.67	.20
.25	.75	.25	.50	.50
.60	.25	.33	.75	.50
.33	.38	.29	.50	.67

(9)				
.74	.40	.67	.38	.22
.67	.38	.57	.50	.50
.44	.29	.67	.57	.80
.60	.50	.67	.40	.33
.50	.50	.25	.50	.25
.44	.38	.33	.50	.50
.50	.33	.67	.50	.50
.33	.60	.33	.50	.40
.67	.67	.33	.67	.50
.40	.50	.29	.50	.67
.23	.30	.67	.67	.25
.50	.50	.50	.50	.25
.50	.50	.50	.57	.50
.43	.60	.50	.50	.67
.40	.50	.75	.50	.50
.33	.57	.67	.80	.17
.38	.38	.33	.33	.50
.67	.75	.50	.67	.50
.40	.50	.50	.67	.60
.43	.50	.67	.75	.67

(4)				
.17	.40	.33	.33	.33
.75	.67	.33	.50	.67
.38	.50	.50	.67	.33
.50	.50	.50	.75	.33
.29	.25	.60	.50	.50
.75	.25	.57	.57	.75
.75	.67	.67	.75	.67
.50	.25	.33	.75	.67
.75	.50	.67	.50	.75
.33	.33	.50	.57	.40
.67	.29	.40	.75	.38
.50	.50	.50	.67	.50
.20	.38	.75	.50	.33
.50	.40	.50	.67	.67
.75	.50	.75	.38	.50
.30	.33	.50	.13	.50
.17	.43	.50	.80	.38
.17	.22	.50	.50	.50
.38	.19	.50	.75	.67
.67	.40	.33	.33	.50

(5)				
.25	.50	.38	.17	.25
.50	.25	.20	.50	.20
.33	.17	.43	.50	.10
.60	.25	.43	.50	.30
.29	.67	.50	.67	.25
.14	.17	.38	.50	.25
.43	.40	.33	.33	.50
.20	.33	.50	.50	.67
.38	.17	.50	.75	.17
.14	.40	.40	.67	.25
.25	.11	.75	.50	.25
.43	.25	.50	.75	.29
.30	.33	.50	.57	.33
.50	.33	.50	.38	.33
.33	.21	.50	.50	.33
.25	.57	.67	.25	.75
.25	.67	.50	.29	.33
.25	.38	.50	.83	.40
.17	.33	.25	.13	.40
.17	.33	.33	.33	.50

(6)				
.40	.25	.38	.33	.38
.33	.75	.25	.67	.50
.40	.33	.38	.50	.33
.17	.75	.20	.33	.17
.14	.29	.60	.50	.50
.83	.60	.50	.33	.20
.62	.38	.38	.50	.40
.50	.57	.40	.40	.38
.40	.60	.67	.33	.33
.75	.75	.57	.43	.40
.71	.17	.25	.40	.50
.36	.31	.50	.29	.75
.50	.50	.67	.21	.38
.25	.25	.50	.50	.25
.43	.30	.50	.60	.50
.33	.40	.25	.30	.33
.50	.33	.40	.44	.25
.75	.50	.40	.75	.50
.22	.50	.50	.50	.50
.67	.33	.80	.57	.44

(10)				
.20	.50	.29	.57	.50
.24	.40	.22	.57	.38
.17	.33	.67	.67	.33
.30	.60	.30	.75	.31
.50	.25	.25	.20	.33
.57	.30	.75	.60	.63
.50	.50	.55	.33	.50
.21	.33	.25	.50	.50
.67	.17	.50	.55	.43
.29	.67	.25	.50	.25
.33	.38	.42	.25	.38
.25	.38	.60	.75	.33
.33	.22	.38	.50	.50
.60	.38	.43	.63	.17
.50	.38	.47	.33	.67
.14	.38	.38	.50	.33
.80	.33	.71	.21	.40
.33	.60	.30	.50	.25
.25	.44	.42	.60	.28
.83	.33	.17	.33	.38

(11)				
.50	.20	.23	.38	.50
.24	.25	.50	.67	.25
.21	.30	.38	.30	.50
.80	.14	.50	.33	.25
.50	.50	.33	.60	.33
.20	.40	.33	.50	.61
.38	.38	.29	.40	.40
.20	.75	.44	.50	.50
.75	.43	.43	.20	.67
.50	.24	.60	.30	.25
.67	.25	.29	.60	.29
.44	.21	.50	.25	.50
.33	.38	.35	.33	.40
.67	.50	.38	.40	.25
.50	.25	.29	.21	.25
.67	.75	.38	.27	.50
.27	.25	.22	.40	.67
.33	.38	.40	.50	.71
.38	.20	.25	.50	.50
.25	.75	.25	.46	.40

Study number in parenthesis.

APPENDIX 2

ELONGATION MEASUREMENTS

(1)

2.67	3.86	2.40	1.54	2.43	1.57
3.33	2.36	2.80	6.00	2.27	2.20
2.00	4.75	2.11	2.57	2.65	3.20
3.25	1.75	2.44	1.33	3.23	1.38
2.78	2.20	1.71	1.93	2.75	3.60
2.54	1.50	1.94	1.29	1.22	2.50
1.90	2.00	3.40	1.11	1.77	2.00
2.38	1.50	1.40	1.36	1.66	2.58
5.00	2.80	2.65	3.00	1.53	4.56
2.00	2.11	2.87	2.08	3.82	1.23
1.50	2.25	2.13	2.50	1.23	5.00
2.13	1.91	2.69	1.88	2.80	1.48
2.18	3.17	2.50	5.17	3.33	1.60
2.33	1.40	1.33	3.25	1.53	4.00
3.75	1.64	3.60	2.67	1.21	2.14
2.33	1.73		2.62	1.53	2.33
3.75	4.57		1.22	2.25	2.38
2.33	6.67		1.85		4.83
1.86	2.67				
1.89	1.33				
2.08	1.83				
2.40	2.63				
2.57	2.39				
2.67					

(2)

1.44	7.00	2.00	2.67	2.25	2.00	5.00
3.00	1.17	2.20	2.25	2.67	1.20	1.40
2.00	1.00	2.00	3.00	2.25	2.67	1.29
1.60	1.83	1.75	1.80	4.50	1.14	2.67
3.11	1.67	1.75	1.67	2.60	2.00	3.20
1.14	1.86	1.91	1.50	1.80	2.00	1.31
1.77	3.75	3.00	1.43	1.56	3.50	2.71
1.88	1.20	2.20	1.60	1.80	1.67	1.50
4.00	1.50	1.83	1.67	2.60	1.50	10.00
1.40	1.40		1.20	3.00	3.33	1.33
1.50	2.27		2.00	1.50	3.20	1.75
4.25	2.25		2.64	2.00	1.25	
5.50	1.40		3.00		2.00	
	1.11		2.00		1.83	
					1.40	
					4.67	
					1.00	
					2.00	
					1.80	
					2.67	
					1.71	
					3.33	

(3)

2.25	1.40	2.40	2.00	2.67
3.75	3.00	1.67	1.75	
1.25	4.00	1.67	1.33	
3.00	1.33	4.50	3.50	
1.60	2.33	1.50	1.80	
1.60	2.00	3.50	2.25	
1.00	1.67	6.50	3.80	
1.50	3.50	1.00	2.25	
2.25	4.25	1.20	1.75	
2.75	4.00	3.00	2.00	
2.40	3.20	2.50	2.20	
3.80	2.33	2.43	3.50	
1.75	1.43	2.14	2.00	
1.13	4.33	1.75	1.00	
1.67	4.20	3.33	1.86	
2.67	3.25	1.75	1.80	
1.33	1.60	1.22	3.50	
3.00	1.83	2.43	1.60	
2.00	2.50	2.25	5.33	
	1.14	1.83	2.60	
	1.25	2.25	2.50	
	5.50		1.65	
	1.67		1.71	
	2.25		1.50	
			2.33	
			3.20	
			1.60	
			3.00	
			1.00	
			1.22	
			5.00	
			1.80	

(4)

1.40	1.47	2.48	1.67	2.50	1.41	2.50	1.58	1.02	2.17
2.20	1.65	1.53	4.58	3.38	1.10	4.20	1.53	2.33	2.67
1.83	1.11	2.67	1.01	5.79	3.00	2.08	1.44	3.13	1.38
1.72	1.37	2.44	2.43	3.17	3.09	2.51	3.68	2.43	1.27
4.43	1.23	2.10	1.18	2.06	2.10	2.26	2.36	2.50	3.27
2.15	2.22	2.07	1.56	2.08	2.13	3.73	2.00		3.52
2.29	2.91	2.24	1.62	2.71	1.32	8.75	3.10		2.19
1.99	1.86	4.71	1.71	1.62	3.00	2.29	4.29		1.56
3.82	2.89	1.64	1.91	2.32	1.29		1.76		
7.00	3.38	1.73	3.32	3.06	1.00		1.19		
2.86	1.33		3.55	1.55	2.77		1.87		
	1.67				1.09				
					2.80				

(5)

2.00	1.00	1.58	2.14	1.86	1.82	1.58	1.83	2.14
2.20	1.17	2.27	1.67	3.09	2.00	1.75	2.80	1.85
2.75	1.67	1.72	1.38	2.50	2.29	1.22	1.19	1.23
1.25	2.00	2.22	2.42	1.00	3.33	1.00	1.00	2.44
1.43	1.47	2.24	3.40	2.21	1.41	1.67	1.67	3.00
3.50	3.29	1.45	2.31	2.83	2.86	1.77	1.04	1.41
1.11	1.82	2.13	1.29	1.30	1.43	2.60	1.67	1.68
1.64	1.50	1.33	1.22	2.41	1.41	1.59	2.05	1.57
	1.82	2.25	2.67	2.77	3.33	1.47	1.51	
	3.67	1.61		2.09	2.32	2.39	4.30	
	1.60			3.00	3.08	2.39		
	1.06			1.81	3.09	2.07		
	2.00			2.00				
	1.86			1.70				
				1.67				
				1.48				

(6)

2.86	2.06	1.67	2.17	1.39	5.00	2.40	2.14	2.80	2.67	2.67	2.44	1.67
2.00	2.67	1.93	4.14	2.83	1.25	1.43	1.62	2.67	1.83	1.10	2.20	2.19
2.33	2.30	2.62	1.88	1.37	1.75	2.67	3.00	1.83	2.17	4.25	1.80	2.29
1.88	1.57	1.83	2.86	2.13	1.73	3.85	2.25	2.17	2.89	1.57	3.00	1.82
1.56	1.80	1.55	2.00	3.75	1.55	3.42	1.83	2.89	2.29	1.88	2.15	2.50
3.60	2.29	2.40	1.75	3.00		3.57	2.42	2.29	2.60	3.57	5.25	2.89
	2.22	1.78	4.20	2.50		4.40	1.71	2.60	2.18	2.36	2.71	1.80
		4.60	2.00	1.29		3.71	1.75	2.18	3.25	3.73	4.50	1.91
			2.18			8.49	2.25	3.25		1.83	2.70	
							3.40				3.27	

Study number in parenthesis.

(7)

3.00	2.93	1.72	3.08	3.91	1.98
1.18	1.50	3.18	3.08	2.00	1.91
1.21	4.77	1.97	3.28	1.46	2.44
2.45	3.35	2.50	1.26	4.71	4.00
3.75	1.71	2.07	2.55	1.53	4.75
1.63	1.33	3.75	3.00	2.41	3.00
2.43	3.14	2.25	2.50	4.33	1.56
2.83	2.00	3.20	1.23	1.24	2.00
1.60	2.80	1.58	5.50	5.50	1.50
3.50	1.69	3.33	3.07	2.17	1.50
2.67	2.01	1.29	2.29	2.52	1.21
2.50	3.00	2.33	1.91	2.50	3.50
2.00	3.86	2.00	10.00	3.10	8.75
2.00	3.00	3.07	1.81	1.10	2.20
1.86	1.77	2.23	2.25	2.00	1.60
1.74			2.53		2.00
			5.64		5.33
			1.36		3.67
			2.11		2.31
			2.08		
			1.67		
			2.80		
			2.43		
			2.33		

(8)

4.29	1.40	1.93	3.80	4.00	1.50	1.71	2.89	1.35	2.67	2.43	1.87	1.68
1.20	2.00	1.57	2.00	1.25	2.69	1.56	1.70	1.01	1.64	5.67	1.68	2.24
4.55	3.17	1.47	1.21	2.15	1.37	1.86	1.38	2.00	1.67	2.23	2.89	1.17
2.14	2.00	2.40	1.20	1.15	2.31	1.64	1.15	1.93	2.22	2.61	1.20	2.09
2.20	1.40		4.27	2.50	1.55	1.52	1.12	2.67	3.94	1.27	1.73	1.03
1.10	1.42		1.78			3.14	2.60	4.40	2.00	1.82	3.86	
1.75	1.63		1.50			1.93	4.40	2.05	1.81	2.72	2.43	
1.89	1.48		1.95			1.53	1.47					
1.94			1.40			3.02	1.94					
3.44			1.56			1.78	1.50					
			2.57			1.46	3.04					
			2.41			5.29	3.10					
						2.38						
						2.07						

(9)

1.29	1.89	1.67	2.57	2.89	2.07	2.00	1.71
2.20	2.44	2.00	2.89	3.44	1.75	3.00	1.80
2.71	3.67	2.07	2.92	2.67	1.80	1.78	1.75
2.00	1.60	2.92	1.92	2.45	2.60	2.64	
1.78	2.08	3.57	4.38	1.69	2.70	1.27	
1.40	2.19	6.00	3.00	1.50	2.22	2.36	
1.11	2.57	1.69	1.50	2.13	2.67	2.42	
2.25	4.00	2.00	2.10	1.57	2.14	1.50	
3.22	4.25	2.80	1.11	2.80	3.20	1.17	
2.00	1.54	2.24	3.11	1.80	2.91	4.29	
2.14	1.18	2.23	3.82	3.79	2.33	2.60	
8.33	2.13	2.33		2.23	5.45		
2.54	2.08	3.50		2.40	2.29		
2.80	2.17	2.00		1.29			
	1.27			2.85			
	3.11						
	2.57						

(10)

1.40	2.17	2.57	5.00	4.00	1.94
2.09	1.85	1.33	1.30	1.57	1.65
1.52	3.20	3.00	2.43	2.10	3.00
1.51	1.78	2.33	5.60	2.58	1.54
2.67	3.92	1.53	1.15	1.54	1.41
2.52	1.78	1.15	1.31	3.37	1.88
2.09	1.61	1.22	1.85	2.78	1.29
1.60	2.70	2.40	2.33	2.38	2.26
	1.81	2.11	2.45	1.98	1.43
	2.45	1.07	2.34	1.94	2.88
	1.58	1.62	2.20	3.71	
	2.80	1.55	4.00		
	2.56	1.40	2.92		
	2.02	1.23	2.39		
	1.95	1.74	1.66		
	1.52	1.51			
	2.11				
	4.25				
	5.50				
	1.08				
	1.90				
	1.56				
	1.50				
	2.38				
	2.52				
	1.07				
	1.79				
	2.27				
	3.96				
	2.91				
	1.98				
	1.36				
	1.10				
	1.03				
	3.00				
	5.49				
	1.25				
	1.60				
	1.60				
	4.16				
	1.41				
	1.63				

(11)

1.52	2.52	2.14	1.38	1.23	1.50	1.92	1.59	1.70	3.12
3.64	1.90	2.00	1.91	2.29	1.96	1.79	1.00	2.50	2.82
2.95	4.70	2.23	1.71	1.33	2.43	2.80	5.00	4.91	1.00
2.85	3.40	1.52	2.38	1.63	1.21	1.89	1.42	2.70	2.60
1.63	2.80	1.14	1.95	1.02	1.67	1.56	1.36	1.33	3.47
1.67	2.35	1.11	2.00	1.54	3.00	3.04	1.83	2.89	1.51
1.68	4.11	3.00	3.51		6.77	2.30	1.02	2.55	2.90
2.07	2.44	1.61	3.98		4.07	1.64	1.95	4.20	2.11
	4.50	3.25	1.43		1.49	1.31	4.20	3.88	
	2.53	2.64	1.11		2.03		2.47	1.94	
			1.41		2.00		3.09	2.83	
							1.95	2.10	
							1.39	1.11	
								6.00	

(12)

1.80	1.71	1.38	2.04	2.80	2.90	1.67	3.54	1.23
2.55	1.55	1.83	3.40	2.00	1.15	2.20	1.64	2.30
3.65	2.52	3.50	1.29	1.56	3.73	1.97	1.42	1.34
4.89	2.54	3.00	1.58	1.36	1.00	1.73	1.72	2.56
2.40	1.32	2.13	2.26	1.68	1.29	3.50	1.94	1.57
1.40	1.43	2.13	2.06	1.50	2.18	1.75	3.44	1.42
4.83	2.33	2.36	1.18	3.67	2.73	2.33		1.42
2.06	1.25	2.74	1.60	1.71	1.79	2.26		2.21
1.17	1.43	2.62	1.27	2.90	3.18	3.53		1.29
1.62	3.19	1.40	2.81	2.29	4.83	2.14		2.27
	4.33	1.40	2.00	1.71		3.25		1.72
		1.35	1.63	2.24		3.43		
			2.33	4.48		2.60		
			5.04	2.14				

Study number in parenthesis.

APPENDIX 3

MEASUREMENTS OF THE TEN LARGEST CLASTS

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)
							(a)	(b)	
26	41	34	32	30	64	50	97	29	110
20	28	38	36	40	49	70	52	37	125
21	39	23	21	26	33	70	36	59	82
18	67	24	18	20	33	33	40	53	74
17	59	23	23	31	43	33	29	47	74
21	19	23	20	20	23	33	34	27	60
19	27	23	21	20	20	45	42	25	66
22	38	22	23	18	16	36	30	26	62
18	14.	21	19	16	21	33	39	38	49
19	18	21	23	16	25	34	32	45	48

(10)	(11)		(12)	(13)		(14)	(15)	(16)		(17)	(18)	
	(a)	(b)		(a)	(b)			(a)	(b)		(a)	(b)
100	51	59	174	36	121	36	115	53	32	27	51	71
80	63	41	64	39	64	30	70	26	145	23	47	35
63	23	32	56	53	59	26	48	30	66	19	45	37
64	74	44	110	25	72	27	39	32	107	18	41	43
60	44	39	59	32	32	36	39	40	77	17	73	59
59	27	34	100	32	36	20	36	33	32	20	44	20
56	25	22	88	31	37	24	32	36	19	15	44	18
54	24	27	83	30	43	28	32	82	27	16	40	25
51	25	23	80	29	46	22	30	57	19	14	32	27
58	31	34	64	30	42	20	29	265	14	17	29	22

(Study Number)

a: Limestone

b: Sandstone

(19)		(20)	(21)	(22)	(23)		(24)	(25)	(26)	(27)
(a)	(b)				(a)	(b)				
35	60	128	58	59	20	26	49	51	63	24
32	36	98	40	45	19	29	115	49	60	44
28	46	86	52	165	24	22	34	36	74	33
32	54	69	41	72	19	18	52	38	66	36
44	62	59	46	33	28	16	48	43	58	24
31	42	65	41	33	22	22	56	55	60	20
30	29	41	36	33	26	32	32	39	63	21
15	27	54	36	39	24	38	83	37	45	19
15	25	40	35	40	17	27	29	36	54	17
16	24	42	36	43	22	20	32	40	70	18

(28)	(29)	(30)	(31)		(32)	(33)	(34)	(35)
			(a)	(b)				
46	32	29	25	26	46	55	69	76
42	41	32	22	14	59	50	43	68
34	39	25	33	16	40	43	49	39
22	35	26	21	33	63	45	59	33
25	59	20	19	27	34	45	43	29
22	38	18	25	24	96	115	39	27
23	31	17	16	22	48	52	43	34
17	36	15	15	15	36	150	40	23
19	36	16	29	16	37	54	51	23
23	47	19	26	23	28	103	39	33

(Study Number)

a: Limestone

b: Sandstone

APPENDIX 4

COMPOSITION OF CONGLOMERATES AND COARSE SANDSTONES

Study Number	1	2	3	4	5	6	7	8	9
Bed Number	2	7	14	18	23	26	33	33	35
Matrix	17.2	24.4	35.2	40.6	30.8	17.5	12.4	12.5	34.5
Grey Micrite	26.1	21.2	28.5	20.7	23.2	28.9	22.9	19.8	25.7
Sandy Limestone	19.8	3.8	11.0	3.4	8.0	15.9	21.4	26.0	13.1
Oolitic and Laminated Limestone		2.7	2.2	2.5	trace			trace	8.5
Biomicrite	6.8	trace	trace		3.0	5.9	6.3	7.2	trace
Sandstone	27.0	6.3	3.3	trace	9.3	25.5	21.4	22.7	9.3
Shale	trace			trace	trace	trace	6.0		trace
Quartz	2.4	40.5	17.3	30.2	21.3	4.4	8.2	2.1	7.7
Others	trace	trace	trace	trace	trace	trace	trace	7.2	trace
Feldspar	trace								

COMPOSITION OF CONGLOMERATES

Study Number	10	11	12	13	14	15	16	17	18
Bed Number	36	49	51	52	55	57	63	65	65
Matrix	15.5	31.5	15.2	12.3	27.6	28.6	22.2	11.6	24.2
Grey Micrite	27.4	33.4	37.8	23.1	34.1	35.3	32.8	20.8	34.3
Sandy Limestone	19.8	13.4	20.4	26.3	28.3	13.4	12.6	26.1	11.5
Oolitic and Laminated Limestone		4.3	trace		6.3	4.2	trace	trace	trace
Biomicrite	3.3	trace	4.0	5.6	5.9	3.0	5.0	7.1	7.8
Sandstone	21.8	6.2	15.4	21.4	trace	6.2	16.3	21.3	14.7
Shale	2.6		2.4	6.3		trace	5.0	9.0	4.1
Quartz	9.1	10.1	3.4	3.3	trace	8.3	5.2	trace	2.3
Others	trace	trace	trace		trace	trace	trace		trace
Feldspar	trace			trace					trace

COMPOSITION OF CONGLOMERATES

COMPOSITION OF SANDSTONES

Bed Number	Study Number	Quartz	Feldspars	Matrix	Cement	Others
19	1	69.3	19.0	0	11.7	0
26	2	74.0	10.3	3.0	12.0	1.7
35	3	65.3	18.4	1.0	14.0	1.3
35	4	56.0	19.0	4.3	18.7	2.0
27	5	68.7	16.4	.3	14.3	.3
50	6	52.3	21.0	7.0	16.0	3.7
50	7	65.3	19.7	2.0	12.3	.7
70	8	63.4	17.0	4.3	13.0	2.3
61	9	59.3	20.0	3.3	14.7	2.7
44	10	70.3	16.7	1.0	11.0	1.0
61	11	60.0	27.0	4.0	6.0	3.0
50	12	60.7	20.9	11.0	4.2	3.2
18	13	65.4	17.0	4.0	12.3	1.3

APPENDIX 5

IMBRICATION MEASUREMENTS

OUTCROP 1A OPERATOR DAVIES
IMBRICATION = 6 STANDARD DEVIATION 13 DEGREES

288	277	273	283	308	292	237	293	294	290	272	231
269	301	235	307	259	342	274	258	294	248	293	295
289	257	269	293	278	295	292	273	242	257	280	292
282	267	284	254	266	245	242	268	246	253	315	324
277	277										

OUTCROP 2A OPERATOR DAVIES
IMBRICATION = 14 STANDARD DEVIATION 4 DEGREES

296	274	258	247	284	282	289	282	283	277	313	294
273	305	295	272	286	305	277	274	287	282	288	288
288											

OUTCROP 3A OPERATOR DAVIES
IMBRICATION = 9 STANDARD DEVIATION 13 DEGREES

280	287	275	237	308	288	277	269	250	281	281	272
275	282	260	282	326	233	315	269	221	291	299	300
266											

OUTCROP 4A OPERATOR DAVIES
IMBRICATION = 15 STANDARD DEVIATION 5 DEGREES

237	283	289	294	301	273	294	294	298	290	278	302
279	272	282	321	294	282	279	294	280	276	279	286
286											

OUTCROP 5A OPERATOR DAVIES
IMBRICATION = 15 STANDARD DEVIATION 6 DEGREES

287	236	291	284	290	293	286	295	293	277	282	312
254	209	289	293	287	285	283	290	296	273	266	301
288											

OUTCROP 6A OPERATOR DAVIES
IMBRICATION = 14 STANDARD DEVIATION 15 DEGREES

277	276	266	280	266	283	336	283	198	242	298	287
291	293	287	303	280	294	255	332	293	297	257	232
312											

OUTCROP 7A OPERATOR DAVIES
IMBRICATION = 13 STANDARD DEVIATION 4 DEGREES

288	225	283	293	282	279	257	284	269	298	287	266
284	272	290	280	277	303	283	282	273	297	271	284
274	281	292	275	279	294	273	268	282	285	269	299
290	299	280	305	285	321	296	289	272	297	281	259
277	296										

OUTCROP 8A OPERATOR DAVIES
IMBRICATION = 16 STANDARD DEVIATION 10 DEGREES

282	313	297	248	262	294	292	277	279	294	295	297
275	326	277	275	277	230	305	318	272	273	287	276
274	267	292	295	293	252	286	292	281	315	313	278
279	263	269	294	325	288	327	296	287	279	280	308
245	305										

OUTCROP 9A OPERATOR DAVIES
IMBRICATION = 7 STANDARD DEVIATION 10 DEGREES

283	274	261	244	250	234	273	295	303	274	256	274
272	247	242	257	230	276	249	308	286	284	309	281
260	276	274	301	292	253	239	300	307	232	276	264
266	249	203	284	249	317	271	248	304	255	296	272
283	254										

OUTCROP 10A OPERATOR DAVIES
IMBRICATION = 12 STANDARD DEVIATION 11 DEGREES

221	236	271	276	274	273	269	222	287	275	288	234
283	272	308	274	299	283	284	287	259	236	327	274
274	295	319	283	275	282	283	309	280	262	245	284
287	294	307	309	292	293	273	286	272	282	276	288
250	243										

OUTCROP 11A OPERATOR DAVIES
IMBRICATION = 19 STANDARD DEVIATION 8 DEGREES

282	293	275	302	275	276	302	278	301	302	328	284
292	289	300	285	290	311	283	281	321	286	277	281
279	284	284	301	272	282	325	283	282	274	270	281
261	285	321	273	278	273	275	294	299	292	292	285
277	279										

OUTCROP 12A OPERATOR DAVIES
IMBRICATION = 12 STANDARD DEVIATION 4 DEGREES

287	284	290	256	275	281	265	286	269	270	265	269
260	286	267	292	300	282	276	281	286	298	302	301
274											

OUTCROP 13A OPERATOR DAVIES
IMBRICATION = 14 STANDARD DEVIATION 12 DEGREES

295	305	283	275	248	283	268	303	282	295	274	303
272	299	281	283	290	279	286	258	294	292	297	326
289	251	254	293	268	262	235	301	255	302	263	259
278	273	274	250	291	321	283	289	329	254	277	274
286	305										

OUTCROP 14A OPERATOR DAVIES
IMBRICATION = 9 STANDARD DEVIATION 14 DEGREES

275	288	287	287	299	284	348	249	263	253	255	287
255	283	281	279	303	273	321	312	244	303	309	242
250											

OUTCROP 15A OPERATOR DAVIES
IMBRICATION = 11 STANDARD DEVIATION 13 DEGREES

305	293	292	265	287	263	289	306	333	300	277	274
269	293	276	266	274	231	289	276	272	221	233	231
314											

OUTCROP 16A OPERATOR DAVIES
IMBRICATION = 9 STANDARD DEVIATION 12 DEGREES

281	232	239	280	292	273	298	293	239	255	290	237
285	245	234	255	266	273	306	283	272	232	265	269
302	251	285	243	287	244	265	241	266	293	290	236
296	276	263	287	286	317	264	253	315	291	266	233
261	283										

OUTCROP 44A OPERATOR WOLFE
IMBRICATION = 8 STANDARD DEVIATION 16 DEGREES

256	273	306	249	250	313	315	227	256	235	226	239
217	239	223	274	287	249	283	292	306	302	342	289
247	254	321	321	267	234	267	221	284	293	280	282
323	285	275	210	260	283	300	270	287	272	243	258
302	263	281	327	321	231	273	279	301	263	297	309
263	265	262	314	279	230	285	251	323	271	260	287
283	249	256	309	252	254	274	276	252	291	282	277
314	223	266	265	224	233	272	312	259	286	283	271
241	279	309	303								

OUTCROP 17A OPERATOR DAVIES
IMBRICATION = 15 STANDARD DEVIATION 4 DEGREES

295	295	272	281	281	296	294	278	284	270	286	296
287	298	277	284	292	300	300	275	302	300	290	279
277	306	290	291	273	297	292	273	260	285	293	295
295	269	273	292	290	302	280	289	284	277	244	303
272	306										

OUTCROP 18A OPERATOR DAVIES
IMBRICATION = 14 STANDARD DEVIATION 6 DEGREES

284	301	279	281	271	302	292	309	288	305	283	233
299	292	275	260	272	290	283	261	286	291	276	310
277	302	274	276	277	283	289	279	270	302	250	269
294	290	284	249	301	290	258	294	291	231	253	232
288	279										

OUTCROP 19A OPERATOR DAVIES
IMBRICATION = - 1 STANDARD DEVIATION 16 DEGREES

293	300	297	253	293	249	221	225	221	269	302	276
274	284	261	213	274	239	257	280	287	279	277	274
299											

OUTCROP 20A OPERATOR DAVIES
IMBRICATION = 12 STANDARD DEVIATION 15 DEGREES

217	307	304	214	273	246	266	259	292	269	258	304
271	298	298	291	304	309	308	303	289	285	300	285
284											

OUTCROP 21A OPERATOR DAVIES
IMBRICATION = 20 STANDARD DEVIATION 8 DEGREES

273	284	295	286	332	297	235	298	299	284	297	297
287	300	288	290	297	269	225	301	304	290	290	303
303	297	280	292	302	283	284	304	290	277	295	299
293	288	282	295	293	287	287	284	290	321	291	277
304	282										

OUTCROP 22A OPERATOR DAVIES
IMBRICATION = 6 STANDARD DEVIATION 10 DEGREES

314	251	265	278	297	232	287	286	286	264	291	297
281	303	256	277	295	279	283	295	299	275	280	270
272	269	292	301	293	273	312	303	307	254	288	221
304	273	286	275	272	292	267	310	272	242	264	255
274	279	278	279	311	293	299	295	249	267	274	269
273	264	251	240	302	268	260	282	273	248	273	254
283	266	219	296	279	285	260	265	271	320	271	270
227	280	253	269	278	292	273	293	276	253	292	259
252	298	250	271								

OUTCROP 22A OPERATOR EGGERTSON
IMBRICATION = 7 STANDARD DEVIATION 10 DEGREES

257	305	282	297	292	266	287	287	288	234	289	279
266	252	314	294	302	293	270	272	270	283	275	283
286	284	279	296	278	274	312	304	309	255	288	222
304	274	287	275	272	292	293	312	279	279	274	256
265	263	272	310	267	293	295	280	250	267	275	270
273	265	251	240	302	262	286	279	287	220	267	254
265	273	262	274	283	261	269	266	272	321	272	270
228	291	253	253	270	292	254	276	290	274	293	279
268	299	251	271								

OUTCROP 23A OPERATOR DAVIES
IMBRICATION = 1 STANDARD DEVIATION 11 DEGREES

283	250	275	262	257	280	308	274	291	247	229	234
277	259	279	294	273	272	292	254	247	251	285	254
272	293	275	278	258	282	267	247	251	248	243	245
275	268	321	267	272	310	270	259	264	239	256	272
259	270	275	283	253	272	281	259	284	272	257	256
242	267	266	226	257	253	246	277	296	285	245	274
315	313	329	244	288	273	269	294	269	294	268	270
257	258	291	283	271	255	263	260	275	317	282	270
284	268	240	292								

OUTCROP 23A OPERATOR WOLFE
IMBRICATION = 1 STANDARD DEVIATION 11 DEGREES

283	250	274	279	257	280	308	274	291	243	228	235
277	260	279	293	273	272	292	255	247	251	286	254
272	234	275	278	259	258	268	247	251	248	241	245
275	269	322	268	272	310	271	260	265	238	256	272
260	270	276	284	252	268	281	259	284	272	257	257
243	267	266	226	257	252	313	316	274	245	285	236
278	245	270	273	288	244	329	271	268	234	269	294
271	283	291	253	257	275	260	264	255	316	282	270
284	260	238	293								

OUTCROP 24A OPERATOR DAVIES
IMBRICATION = 10 STANDARD DEVIATION 8 DEGREES

242	272	273	330	273	273	285	300	271	272	303	273
272	271	273	259	264	286	295	271	300	302	283	283
300	290	288	304	273	271	241	293	277	276	288	280
297	285	257	275	235	236	253	270	275	276	264	274
277	277	299	272	271	271	270	270	287	287	299	317
304	299	303	267	284	284	298	274	273	277	295	276
274	267	284	286	272	258	264	293	276	260	272	260
291	291	270	286	272	294	287	295	299	303	291	230
276	260	290	288								

OUTCROP 24A OPERATOR EGGERTSON
IMBRICATION = 11 STANDARD DEVIATION 8 DEGREES

302	299	271	295	288	264	259	272	271	271	272	304
271	271	300	295	272	273	331	272	271	241	283	232
300	290	287	307	273	271	241	292	277	276	287	231
297	286	258	275	235	295	253	270	287	287	270	270
271	271	273	299	276	276	273	265	276	274	299	316
305	299	304	273	284	233	298	274	267	277	295	276
274	267	284	290	291	303	289	295	287	294	272	286
270	291	291	280	273	270	277	292	264	258	272	285
275	260	281	292								

OUTCROP 25A OPERATOR DAVIES
IMBRICATION = 7 STANDARD DEVIATION 10 DEGREES

257	275	265	267	289	266	294	247	249	248	267	283
273	226	271	260	262	273	297	301	310	276	287	252
276	267	310	247	284	293	281	275	283	296	271	272
284	274	273	308	329	319	297	297	276	294	272	300
258	258	257	267	265	265	262	270	311	271	275	252
270	270	267	270	240	272	307	291	276	273	273	285
271	274	259	272	268	273	294	299	262	286	303	313
307	283	262	255	306	272	269	295	234	300	312	274
281	274	290	275								

OUTCROP 25A OPERATOR EGGERTSON
IMBRICATION = 7 STANDARD DEVIATION 10 DEGREES

294	282	275	280	292	284	247	310	267	276	251	287
276	309	271	279	284	274	273	308	328	317	287	287
276	294	271	300	293	267	264	274	254	252	275	271
311	270	262	265	265	266	257	258	259	266	294	247
248	249	267	282	273	227	271	269	242	278	287	300
271	259	270	271	285	273	273	276	231	307	272	239
269	266	272	272	243	273	293	299	249	297	303	313
307	283	261	254	226	295	283	275	231	274	281	274
312	302	324	295								

OUTCROP 26A OPERATOR EGGERTSON
IMBRICATION = 4 STANDARD DEVIATION 11 DEGREES

328	267	231	270	297	295	275	291	287	246	285	277
269	267	243	294	283	231	305	299	230	272	272	270
324	275	311	259	263	289	274	274	271	232	276	291
269	263	263	290	281	280	292	270	233	246	272	262
253	245	283	291	314	302	273	288	223	244	263	270
270	269	274	269	273	269	270	270	253	275	239	284
262	219	271	299	291	276	234	272	273	273	243	264
248	292	243	264	258	238	295	310	240	269	272	267
270	246	266	264								

OUTCROP 27A OPERATOR EGGERTSON
IMBRICATION = 9 STANDARD DEVIATION 8 DEGREES

276	233	279	305	283	287	279	278	275	276	272	302
287	269	274	268	284	233	283	286	270	276	275	267
271	263	298	290	247	281	249	249	262	295	263	330
271	283	254	272	263	278	277	276	325	257	244	296
303	270	285	294	295	268	262	264	273	267	323	262
289	290	273	313	320	267	300	299	287	277	277	263
290	279	262	299	277	293	226	282	247	290	241	245
258	292	313	269	294	295	276	291	289	285	251	250
283	285	257	277								

OUTCROP 28A OPERATOR WOLFE
IMBRICATION = 7 STANDARD DEVIATION 12 DEGREES

289	296	287	265	273	281	287	312	275	292	316	258
262	271	311	277	267	267	272	269	234	289	273	274
285	296	272	296	287	287	277	296	247	248	283	270
250	276	271	311	263	263	234	314	277	281	240	341
231	285	287	299	279	266	287	246	234	295	277	301
293	259	287	224	245	312	260	260	308	229	261	270
268	270	295	270	277	238	283	304	257	280	293	254
228	287	283	292	247	299	288	300	271	283	307	319
292	244	287	287								

OUTCROP 29A OPERATOR WOLFE
IMBRICATION = 4 STANDARD DEVIATION 10 DEGREES

286	263	263	274	274	281	285	308	270	260	283	281
271	283	273	277	286	244	303	281	273	228	243	270
288	251	271	288	275	255	272	272	272	257	273	277
289	300	293	291	284	271	326	289	275	266	265	255
307	273	273	297	285	277	291	304	296	255	256	309
271	271	303	280	240	272	277	270	274	261	284	260
262	271	264	279	273	267	284	264	277	308	323	256
262	272	245	251	255	269	253	264	275	271	335	294
266	252	262	271								

OUTCROP 30A OPERATOR EGGERTSON
IMBRICATION = 3 STANDARD DEVIATION 13 DEGREES

298	315	242	280	271	248	272	345	341	250	290	298
280	277	271	296	272	274	294	289	272	295	287	285
244	260	291	288	293	300	301	276	254	341	250	319
314	301	309	279	291	261	279	292	294	280	245	269
294	211	249	301	273	277	224	272	309	273	219	261
259	276	294	287	279	250	269	294	275	272	294	310
288	247	290	270	222	301	268	267	267	272	279	267
252	246	293	270	277	279	258	297	270	280	281	266
237	312	277	269								

OUTCROP 31A OPERATOR WOLFE
IMBRICATION = - 2 STANDARD DEVIATION 14 DEGREES

268	269	261	226	235	207	271	300	271	306	285	215
267	293	294	283	250	263	271	265	298	269	320	257
269	275	235	261	267	290	319	260	240	280	273	270
247	239	273	235	243	271	255	273	290	325	241	239
269	278	293	216	292	282	227	259	250	271	267	264
265	279	273	279	280	276	272	248	271	236	277	238
269	255	252	254	295	277	226	263	235	293	279	297
280	303	295	234	302	270	296	289	263	244	260	250
255	272	251	256								

OUTCROP 32A OPERATOR WOLFE
IMBRICATION = 4 STANDARD DEVIATION 14 DEGREES

269	304	272	275	274	280	271	287	334	246	279	278
256	215	296	294	253	343	258	259	272	270	304	272
244	273	345	311	300	276	272	272	269	295	304	234
269	239	244	291	247	260	272	257	294	269	257	329
271	290	313	232	257	276	299	275	295	285	238	243
287	274	280	293	245	272	257	261	236	280	293	274
271	270	273	302	300	268	249	269	333	262	228	211
251	266	252	232	231	262	279	251	242	236	267	280
299	297	233	312								

OUTCROP 33A OPERATOR EGGERTSON
IMBRICATION = 2 STANDARD DEVIATION 14 DEGREES

247	265	333	275	274	274	287	259	270	277	276	261
255	264	283	242	272	248	260	390	248	318	215	272
245	259	263	281	251	244	277	270	254	271	290	292
312	278	258	197	257	274	290	270	260	255	302	255
281	267	264	294	231	309	276	295	322	310	290	255
264	263	262	273	226	273	312	275	246	295	293	296
237	296	239	306	249	276	263	268	249	282	286	299
315	275	313	286	253	255	304	251	256	277	273	255
278	242	233	266								

OUTCROP 34A OPERATOR WOLFE
IMBRICATION = - 1 STANDARD DEVIATION 10 DEGREES

249	287	231	248	245	252	267	290	261	264	267	254
302	264	264	259	233	269	292	259	249	292	235	261
296	238	267	273	265	269	263	214	292	270	264	254
255	263	279	273	260	249	287	249	264	262	260	226
265	270	269	288	270	268	234	270	251	293	234	260
293	298	269	297	295	271	292	291	279	275	239	260
281	269	254	234	301	297	315	269	271	283	281	281
270	295	262	264	269	249	240	278	270	313	251	260
310	273	239	274								

OUTCROP 35A OPERATOR EGGERTSON
IMBRICATION = - 2 STANDARD DEVIATION 11 DEGREES

276	256	276	250	287	288	257	224	235	226	257	264
273	275	263	247	275	266	264	249	263	299	270	273
295	264	254	297	269	282	271	273	252	267	285	275
286	291	255	249	208	284	273	265	255	268	273	226
305	273	268	273	270	265	274	260	268	270	228	273
286	278	278	263	286	252	280	264	275	239	266	265
269	260	238	252	256	245	243	296	252	299	300	210
280	298	260	226	260	273	255	268	307	319	317	293
264	303	301	263								

OUTCROP 36A OPERATOR WOLFE
IMBRICATION = 12 STANDARD DEVIATION 11 DEGREES

245	281	280	238	247	256	233	269	270	275	249	313
289	276	270	300	269	274	307	274	270	316	272	296
297	306	306	298	261	285	284	275	272	292	279	263
294	268	251	263	286	293	322	293	293	294	303	300
291	250	289	284	295	299	304	303	279	327	294	292
266	296	289	220	276	289	299	291	277	299	319	288
303	317	277	233	310	296	290	262	290	275	295	278
303	272	244	226	272	258	294	262	288	299	274	250
279	277	245	289								

OUTCROP 37A OPERATOR EGGERTSON
IMBRICATION = - 6 STANDARD DEVIATION 12 DEGREES

262	253	243	262	260	224	273	274	299	285	272	257
288	295	270	238	255	301	280	270	278	315	224	243
257	243	260	232	342	254	246	250	234	297	269	273
248	267	256	239	272	232	265	219	273	226	254	279
255	273	272	254	279	298	232	263	243	267	254	255
294	260	267	269	272	322	260	311	294	255	253	235
253	262	242	272	267	239	290	241	250	255	259	268
239	244	245	237	284	243	254	272	295	254	265	284
284	250	257	323								

OUTCROP 38A OPERATOR DAVIES
IMBRICATION = 8 STANDARD DEVIATION 13 DEGREES

264	306	296	254	281	261	290	225	332	306	290	261
285	271	312	244	318	291	311	278	300	250	280	261
254	310	275	265	225	248	296	224	221	288	294	312
277	259	275	293	260	280	290	288	299	281	281	249
290	276	293	275	310	283	281	275	293	255	259	272
260	313	299	254	256	267	275	295	256	297	237	237
269	317	277	314	290	267	309	235	293	300	298	290
268	272	289	312	312	310	261	316	277	259	248	277
291	282	293	274								

OUTCROP 38A OPERATOR EGGERTSON
IMBRICATION = 5 STANDARD DEVIATION 12 DEGREES

287	252	274	305	263	260	279	233	300	305	289	260
283	269	310	243	223	290	210	276	279	258	291	274
257	275	310	282	296	222	223	284	247	225	263	273
308	252	260	278	248	233	278	286	296	279	279	247
288	274	292	273	307	287	279	273	290	253	257	270
250	312	298	252	255	299	291	233	307	266	252	312
275	315	266	237	236	295	254	284	274	265	297	288
266	272	289	310	310	309	314	260	275	256	246	275
289	256	291	272								

OUTCROP 39A OPERATOR EGGERTSON
IMBRICATION = 5 STANDARD DEVIATION 8 DEGREES

293	273	277	299	290	279	277	295	274	290	285	285
272	273	263	245	220	256	271	296	287	271	272	246
276	273	287	286	251	271	271	267	272	257	275	241
281	262	305	293	292	291	248	273	275	274	272	296
274	271	272	277	273	300	301	260	288	296	287	311
269	269	247	274	310	289	277	272	270	300	270	268
266	273	266	265	304	294	276	289	277	280	200	270
291	251	294	249	272	290	285	283	276	261	255	259
274	271	288	277								

OUTCROP 40A OPERATOR WOLFE
IMBRICATION = 1 STANDARD DEVIATION 12 DEGREES

254	253	259	254	276	277	254	257	262	261	256	270
268	251	283	279	263	275	262	290	238	273	274	301
284	233	249	299	271	299	248	280	271	293	272	266
237	286	265	337	283	259	273	290	284	232	270	274
277	258	269	280	227	262	272	324	261	250	287	283
283	278	276	275	298	295	270	247	261	263	258	294
247	218	218	288	273	254	271	320	250	260	289	276
269	280	272	269	317	224	298	285	254	279	247	322
290	288	267	244								

OUTCROP 41A OPERATOR EGGERTSON
IMBRICATION = 7 STANDARD DEVIATION 11 DEGREES

292	305	287	288	277	302	259	313	276	226	268	261
270	306	321	299	275	280	274	296	293	267	261	280
278	256	267	273	299	290	323	257	279	243	282	273
270	275	295	259	288	284	303	298	273	237	270	286
272	266	273	249	275	250	287	301	276	259	254	252
267	269	307	270	296	286	273	275	297	259	270	230
281	301	273	297	243	261	292	296	273	299	272	302
288	270	233	266	282	298	279	297	260	303	319	260
281	231	293	245								

OUTCROP 42A OPERATOR WOLFE
IMBRICATION = 4 STANDARD DEVIATION 6 DEGREES

271	271	320	265	282	284	257	270	275	266	269	283
297	274	284	285	260	254	267	254	287	285	277	240
273	292	261	284	275	272	268	280	286	266	291	292
284	274	271	280	260	273	280	281	296	270	277	273
281	244	273	245	268	267	247	256	294	276	277	260
267	291	280	279	274	270	259	274	285	271	283	270
270	260	284	279	272	265	249	277	259	253	286	283
328	290	253	257	278	297	262	259	250	298	273	288
286	313	247	297								

OUTCROP 43A OPERATOR EGGERTSON
IMBRICATION = 8 STANDARD DEVIATION 13 DEGREES

324	260	289	266	260	290	328	303	256	246	241	310
284	271	265	256	240	303	251	203	251	274	323	246
253	262	265	251	280	273	265	249	265	246	270	260
266	257	240	315	272	274	238	272	332	260	260	284
263	270	260	292	264	273	288	292	283	271	283	223
288	303	311	260	293	298	334	270	276	263	243	260
306	320	287	280	307	273	245	315	288	260	279	272
291	283	288	255	277	313	276	327	273	291	283	255
285	295	312	213								

APPENDIX 6

ORIENTATION MEASUREMENTS

OUTCROP 1 OPERATOR EGGERTSON
VECTOR MEAN = 241 STANDARD DEVIATION 20 DEGREES

214	224	240	261	257	234	237	257	258	275	238	253
235	350	239	226	211	231	357	239	254	263	244	200
187	236	262	247	255	234	254	255	226	216	258	236
187	246	233	209	243	248	201	259	224	226	247	218
237	349	211	355	357	207	246	242	237	233	230	231
290	256	340	191	350	223	189	243	343	263	231	263
230	232	263	185	193	232	183	240	243	255	228	249
255	244	198	244	236	204	242	251	230	231	230	249
210	231	243	248								

OUTCROP 2 OPERATOR EGGERTSON
VECTOR MEAN = 232 STANDARD DEVIATION 14 DEGREES

235	252	241	240	233	243	229	225	229	236	224	208
196	222	226	282	276	313	236	233	242	191	241	239
261	300	247	263	247	240	213	249	244	267	272	234
217	166	163	199	203	207	220	231	247	250	278	250
237	242	231	204	234	263	233	255	243	241	235	231
236	225	225	232	233	217	239	244	212	212	239	244
215	226	237	228	221	209	244	211	225	231	262	188
261	253	220	196	212	208	192	222	238	208	197	236
230	193	236	214								

OUTCROP 3 OPERATOR WOLFE
VECTOR MEAN = 232 STANDARD DEVIATION 18 DEGREES

222	228	204	221	224	235	219	199	345	245	189	217
218	212	253	233	233	222	224	218	225	227	228	208
223	193	254	215	265	250	213	253	225	218	207	248
243	223	254	222	254	209	238	231	239	253	228	233
353	236	320	207	248	221	245	254	234	199	229	228
239	235	204	228	351	255	199	234	274	229	236	253
266	225	248	247	262	358	246	193	187	259	198	238
248	353	250	220	194	233	227	227	218	202	239	209
207	182	351	240								

OUTCROP 4 OPERATOR EGGERTSON

254	215	242	213	351	261	221	182	191	231	249	203

VECTOR MEAN = 231 STANDARD DEVIATION 22 DEGREES

210	196	239	240	250	198	255	255	344	330	232	229
219	197	220	236	223	213	255	204	272	242	274	268
204	250	256	200	212	240	227	200	238	353	198	224
221	244	203	236	250	251	228	191	225	183	258	219
266	233	192	192	233	228	245	249	230	207	207	205
228	193	232	180	291	193	191	350	188	186	359	226
247	227	259	213	213	205	227	236	252	227	249	207
214	312	190	212								

OUTCROP 5 OPERATOR WOLFE
VECTOR MEAN = 239 STANDARD DEVIATION 16 DEGREES

222	191	233	248	242	195	280	240	216	240	259	217
244	261	351	224	245	241	266	228	245	234	271	191
235	244	208	236	219	234	221	218	257	204	238	252
229	242	342	223	232	344	228	231	243	226	260	340
231	232	234	234	247	231	245	193	253	209	223	247
240	251	242	252	243	255	217	192	248	291	243	242
238	234	237	254	228	268	240	245	239	239	237	210
234	243	206	277	255	214	211	199	261	252	289	246
228	245	206	218								

OUTCROP 6 OPERATOR EGGERTSON
VECTOR MEAN = 226 STANDARD DEVIATION 17 DEGREES

261	258	205	208	250	221	208	227	257	203	207	232
225	195	228	224	238	253	181	225	221	227	224	202
247	210	227	223	202	189	201	225	270	223	212	356
257	358	184	228	200	233	233	210	348	268	231	247
210	228	238	240	230	231	203	218	205	236	238	192
229	207	262	201	218	352	207	242	237	223	224	225
222	231	228	256	199	193	247	268	204	222	352	214
199	226	207	201	248	229	239	215	240	182	253	234
195	211	230	205								

OUTCROP 7 OPERATOR WOLFE
VECTOR MEAN = 240 STANDARD DEVIATION 17 DEGREES

249	246	186	226	261	231	208	214	209	316	230	222
209	277	251	238	212	221	241	244	195	261	250	300
265	204	221	199	256	221	245	233	256	209	212	237
223	285	204	225	227	235	250	230	248	247	250	230
228	282	264	222	208	311	229	205	224	237	220	282
196	213	208	201	225	277	256	252	218	202	210	212
239	304	255	201	264	226	236	238	245	262	197	220
262	274	206	215	243	229	240	206	247	226	267	250
239	229	243	226								

OUTCROP 8 OPERATOR EGGERTSON
VECTOR MEAN = 244 STANDARD DEVIATION 19 DEGREES

252	270	251	236	318	215	346	269	237	247	227	259
192	214	242	220	231	247	255	209	205	233	252	254
265	283	348	224	218	237	257	232	193	213	211	242
257	276	236	217	305	248	234	247	283	224	196	194
238	268	210	234	250	347	198	256	272	264	247	262
262	245	227	273	290	236	180	284	248	241	249	257
257	301	282	287	303	196	190	230	227	209	285	303
233	198	205	234	263	195	195	238	256	217	235	220
238	240	237	242								

OUTCROP 9 OPERATOR WOLFE
VECTOR MEAN = 242 STANDARD DEVIATION 17 DEGREES

249	284	265	242	182	250	197	235	297	274	222	242
277	274	224	273	262	255	237	234	235	236	240	249
243	195	247	241	261	246	296	204	233	228	242	210
237	264	238	224	234	195	184	299	241	254	241	232
212	255	250	236	231	273	257	251	265	219	235	210
242	231	251	251	235	217	217	253	236	202	249	185
250	221	226	217	272	225	194	223	256	196	209	236
260	207	236	243	344	257	201	199	341	245	288	229
242	257	243	197								

OUTCROP 10 OPERATOR WOLFE
VECTOR MEAN = 221 STANDARD DEVIATION 13 DEGREES

229	196	217	222	214	219	248	331	222	219	215	221
259	223	207	266	229	226	203	232	225	232	234	209
226	227	225	241	208	211	198	224	222	206	207	223
222	213	183	254	230	234	220	212	203	216	241	219
228	205	192	230	220	228	215	218	187	222	225	236
203	248	223	256	228	152	189	202	200	213	213	219
194	355	215	204	258	244	217	218	201	229	227	223
216	213	217	229	201	234	198	226	236	251	220	202
217	282	194	233								

OUTCROP 11 OPERATOR EGGERTSON
VECTOR MEAN = 241 STANDARD DEVIATION 23 DEGREES

224	221	346	226	242	247	250	243	250	206	333	353
236	241	355	273	257	259	196	266	202	211	349	205
184	348	186	193	265	224	211	243	211	210	253	217
227	217	331	292	237	263	244	220	242	206	243	240
208	215	249	243	238	243	216	345	189	261	348	231
342	224	258	244	225	288	204	230	196	271	253	199
268	191	348	224	228	224	275	321	232	265	235	246
235	229	280	190	207	229	218	233	193	236	251	243
226	288	227	240								

OUTCROP 12 OPERATOR WOLFE
VECTOR MEAN = 245 STANDARD DEVIATION 14 DEGREES

227	242	270	219	207	206	223	256	348	263	243	195
226	239	238	246	252	257	226	290	248	271	238	239
245	326	245	257	254	254	261	258	262	298	253	261
198	278	242	245	254	229	199	238	251	207	256	255
266	248	253	225	190	253	253	201	265	265	288	268
237	242	270	281	249	224	219	217	239	209	254	215
219	268	252	246	246	251	235	247	232	248	231	274
222	213	247	231	236	238	255	275	259	247	251	237
224	241	216	282								

OUTCROP 13 OPERATOR EGGERTSON
VECTOR MEAN = 228 STANDARD DEVIATION 17 DEGREES

260	263	278	305	240	250	250	234	233	256	231	284
236	274	273	275	243	273	262	232	274	239	238	237
252	259	239	254	219	201	189	215	228	204	196	225
210	212	227	200	206	203	195	213	221	225	203	217
228	227	219	200	201	188	221	218	228	226	217	203
230	229	182	189	193	225	217	353	211	216	180	359
216	208	219	226	213	211	243	219	217	205	221	220
213	233	231	282	238	227	214	235	296	214	346	214
243	234	180	185								

OUTCROP 14 OPERATOR EGGERTSON
VECTOR MEAN = 237 STANDARD DEVIATION 15 DEGREES

306	235	231	220	251	237	247	234	248	218	221	223
278	330	232	207	239	231	248	215	245	270	237	248
292	216	214	208	238	190	191	213	242	215	247	260
211	214	215	258	205	200	258	236	261	231	201	229
211	227	264	254	242	238	270	229	231	227	269	243
262	239	258	251	243	210	231	219	276	240	231	221
238	218	226	219	254	194	205	237	277	229	255	359
252	219	231	232	264	230	229	242	223	207	239	231
251	241	219	294								

OUTCROP 15 OPERATOR WOLFE
VECTOR MEAN =242 STANDARD DEVIATION 17 DEGREES

221	234	274	211	203	262	249	202	231	246	215	265
252	237	254	185	239	249	288	207	256	231	211	211
282	274	229	218	312	226	345	236	241	237	247	259
256	199	212	205	226	191	228	262	246	238	242	264
254	271	264	253	232	279	258	257	241	253	359	247
183	237	247	252	295	243	242	251	244	200	227	200
222	209	270	250	288	234	228	266	235	244	240	357
227	229	238	244	226	228	223	222	185	237	288	218
257	343	238	226								

OUTCROP 16 OPERATOR EGGERTSON
VECTOR MEAN = 244 STANDARD DEVIATION 19 DEGREES

256	238	272	193	265	241	309	273	268	227	220	248
246	207	181	234	304	232	253	234	220	193	217	243
247	238	217	214	218	209	249	283	220	227	242	238
197	284	228	284	220	257	235	250	218	273	258	277
260	272	288	212	269	245	203	234	240	352	199	270
222	240	222	265	210	356	233	343	251	282	266	242
298	279	355	239	227	262	234	181	195	215	244	298
290	210	272	228	201	249	223	243	240	268	240	231
248	240	236	239								

OUTCROP 17 OPERATOR WOLFE
VECTOR MEAN = 239 STANDARD DEVIATION 19 DEGREES

280	197	207	232	191	236	229	255	215	218	208	258
247	217	237	211	242	246	248	271	221	260	241	269
276	265	197	236	243	358	251	260	220	330	233	269
334	218	240	273	245	236	223	223	231	218	220	226
209	188	260	183	188	306	239	237	301	263	234	233
215	309	181	253	237	355	271	214	276	219	289	221
202	222	233	290	233	228	261	235	254	238	285	227
254	226	194	235	232	200	231	288	233	214	234	216
213	264	219	259								

OUTCROP 18 OPERATOR WOLFE
VECTOR MEAN = 253 STANDARD DEVIATION 17 DEGREES

267	248	224	274	225	256	268	255	243	269	238	221
292	272	316	249	272	269	239	240	224	276	253	237
269	289	242	225	225	264	296	244	335	253	227	229
247	276	230	251	294	225	221	241	226	232	246	238
272	241	235	246	251	205	272	266	269	250	321	260
351	276	311	280	249	255	238	243	288	224	260	241
243	271	239	237	270	244	254	242	235	198	357	282
185	249	229	220	244	352	248	349	240	218	285	271
222	256	227	235								

OUTCROP 19 OPERATOR EGGERTSON
VECTOR MEAN = 241 STANDARD DEVIATION 16 DEGREES

231	221	242	246	248	238	237	241	184	248	237	304
222	226	225	261	229	210	184	283	352	226	239	257
213	202	223	209	220	218	278	243	215	237	247	287
248	217	244	210	215	230	235	238	198	250	238	257
228	233	221	260	275	241	243	243	266	266	203	275
215	231	268	264	259	216	195	228	228	270	210	198
257	218	275	276	234	281	279	238	258	252	227	290
252	288	260	288	248	213	210	276	230	251	253	255
246	245	257	200								

OUTCROP 20 OPERATOR WOLFE
VECTOR MEAN = 256 STANDARD DEVIATION 21 DEGREES

250	316	196	281	257	252	257	234	195	254	223	260
245	261	237	189	272	244	237	310	349	215	247	243
275	229	236	272	253	294	205	245	247	255	286	333
203	241	241	270	232	233	253	334	345	257	211	234
239	257	231	286	241	272	275	254	240	185	193	264
262	261	249	260	260	270	264	267	332	230	259	189
286	357	233	297	236	236	355	316	259	267	257	236
244	308	242	241	207	314	201	197	319	219	228	274
198	258	357	201								

OUTCROP 21 OPERATOR DAVIES
VECTOR MEAN = 239 STANDARD DEVIATION 12 DEGREES

214	238	237	253	282	272	240	225	241	238	235	211
241	241	226	283	272	241	211	224	211	213	237	245
265	269	272	254	232	215	227	209	207	236	234	251
270	238	261	226	263	205	220	258	223	334	254	228
227	238	250	260	314	227	230	222	240	282	242	232
223	212	237	247	232	218	246	255	257	236	226	238
234	243	214	247	248	244	242	238	229	244	235	211
223	241	208	265	233	222	224	225	208	237	245	248
243	245	233	238								

OUTCROP 21 OPERATOR WOLFE
VECTOR MEAN = 239 STANDARD DEVIATION 12 DEGREES

241	225	239	232	283	253	236	289	213	238	235	212
241	241	231	269	265	245	237	213	211	214	211	241
272	234	272	254	232	215	228	208	209	237	234	251
271	237	260	225	263	205	226	314	261	250	238	223
227	224	235	237	258	220	230	239	240	282	241	233
223	212	237	247	232	217	246	255	257	265	208	241
223	212	236	245	230	239	243	246	248	242	214	243
235	233	225	237	233	222	224	224	209	238	245	249
243	255	232	238								

OUTCROP 22 OPERATOR WOLFE
VECTOR MEAN = 250 STANDARD DEVIATION 19 DEGREES

256	254	265	266	275	233	260	271	230	209	254	231
280	224	290	242	290	258	269	218	194	249	264	275
214	211	274	352	236	207	250	277	282	277	266	354
212	210	261	284	278	274	294	286	241	237	225	350
195	243	236	236	196	249	243	250	246	311	233	268
225	213	271	197	259	355	242	243	199	239	237	279
271	223	243	245	183	286	242	241	195	187	193	259
227	223	244	294	194	267	214	251	266	214	275	261
203	254	250	240								

OUTCROP 23 OPERATOR EGGERTSON
VECTOR MEAN = 236 STANDARD DEVIATION 13 DEGREES

246	233	241	230	237	246	243	271	213	208	210	235
217	223	261	260	235	250	236	214	255	206	219	223
243	220	240	257	211	232	248	246	224	216	213	219
231	225	219	240	232	302	254	229	231	246	235	214
230	228	257	215	208	198	206	196	229	253	233	252
253	233	233	270	232	231	258	199	217	209	345	252
254	262	249	237	255	262	219	218	226	233	235	249
241	194	208	248	244	246	254	222	278	269	295	251
199	247	264	246								

OUTCROP 24 OPERATOR WOLFE
VECTOR MEAN = 233 STANDARD DEVIATION 14 DEGREES

272	251	267	248	234	222	246	206	240	203	255	240
255	224	233	252	223	264	218	239	198	200	222	236
244	207	244	219	193	223	221	239	277	254	216	192
185	215	230	232	220	353	234	255	239	358	234	254
216	222	231	192	216	231	258	232	218	235	239	228
230	233	251	227	229	204	229	240	234	223	241	206
235	231	277	255	191	217	224	260	254	253	218	234
230	230	211	256	220	248	202	216	245	248	246	241
272	139	267	255								

OUTCROP 25 OPERATOR WOLFE
VECTOR MEAN = 237 STANDARD DEVIATION 16 DEGREES

185	138	352	199	265	233	275	253	248	183	230	235
205	256	229	228	256	259	234	242	238	241	232	238
238	233	233	232	254	258	255	216	228	241	265	248
245	232	255	218	207	215	357	235	216	241	216	211
235	233	223	226	219	220	257	209	223	245	209	252
262	240	250	230	253	240	190	263	242	243	237	237
245	223	358	249	192	194	196	245	251	244	243	246
255	250	279	236	249	254	216	226	204	196	246	233
232	248	225	239								

OUTCROP 26 OPERATOR EGGERTSON
VECTOR MEAN = 233 STANDARD DEVIATION 6 DEGREES

246	257	247	230	258	229	236	235	243	199	225	205
235	233	215	240	243	240	249	232	278	233	229	220
209	233	221	213	238	252	249	238	247	244	228	243
242	241	219	209	219	233	236	239	235	232	240	237
239	237	259	214	236	216	217	229	209	223	221	214
235	232	228	244	239	238	254	249	225	221	237	204
244	215	249	228	201	223	228	239	243	247	229	229
227	223	252	248	243	244	253	254	224	221	220	232
231	233	214	214								

OUTCROP 27 OPERATOR WOLFE
VECTOR MEAN = 220 STANDARD DEVIATION 11 DEGREES

220	211	223	262	223	187	193	248	227	238	218	206
221	207	230	233	204	221	224	276	225	226	211	200
215	241	191	227	213	261	357	189	280	209	226	225
222	136	232	220	252	219	226	245	206	222	219	237
218	217	228	214	221	235	203	223	192	217	204	227
208	229	215	215	210	220	226	223	223	261	214	221
193	215	215	245	217	216	219	228	217	194	228	220
182	220	227	245	234	210	210	214	214	193	197	186
227	220	213	229								

OUTCROP 28 OPERATOR WOLFE
VECTOR MEAN = 233 STANDARD DEVIATION 13 DEGREES

270	206	262	236	232	237	225	216	247	222	216	228
227	258	215	274	271	222	239	187	185	208	231	244
224	237	262	233	227	226	240	234	253	226	239	195
248	258	209	239	250	204	212	253	227	253	231	250
215	253	209	246	219	241	213	352	225	190	245	224
220	237	255	253	235	265	214	254	227	232	219	223
250	224	242	221	238	244	237	238	232	243	269	204
216	247	213	352	224	236	251	201	208	233	211	240
235	226	227	224								

OUTCROP 29 OPERATOR EGGERTSON
VECTOR MEAN = 233 STANDARD DEVIATION 17 DEGREES

345	228	242	221	224	221	222	252	241	203	223	240
291	217	223	220	274	207	225	267	348	236	271	227
232	250	192	225	271	213	227	222	257	223	354	222
227	218	232	233	252	223	208	250	217	333	224	226
237	213	215	220	243	224	212	203	275	213	259	272
261	252	209	209	232	250	252	233	231	251	273	222
228	240	224	222	221	232	240	203	235	213	207	205
221	234	228	225	301	217	238	239	241	217	308	247
218	131	210	182								

OUTCROP 30 OPERATOR EGGERTSON
VECTOR MEAN = 236 STANDARD DEVIATION 17 DEGREES

347	203	231	223	221	220	304	217	236	243	292	238
231	220	222	262	263	221	229	193	214	193	194	231
205	230	228	232	216	233	226	228	249	237	356	253
230	228	222	244	232	230	272	278	237	231	232	242
192	292	306	251	244	221	224	216	221	234	347	222
227	193	223	211	252	295	231	191	199	284	228	249
239	212	203	217	218	207	256	280	216	225	224	221
219	237	243	239	236	235	221	271	266	218	235	226
229	297	298	237								

OUTCROP 31 OPERATOR EGGERTSON
VECTOR MEAN = 252 STANDARD DEVIATION 15 DEGREES

263	242	269	290	265	222	239	273	244	243	265	265
269	249	194	299	259	250	234	197	242	278	224	232
255	248	267	263	240	247	239	258	243	247	235	234
238	292	294	241	253	225	259	252	244	269	209	234
193	240	303	271	274	255	302	302	256	254	244	244
253	235	239	244	212	237	270	263	251	203	240	256
253	258	209	297	274	236	240	238	255	225	231	230
228	263	232	246	253	268	269	358	237	254	238	228
246	214	245	250								

OUTCROP 32 OPERATOR WOLFE
VECTOR MEAN = 245 STANDARD DEVIATION 19 DEGREES

193	203	220	351	240	253	193	226	247	233	256	229
257	245	257	213	243	256	252	230	257	231	227	271
275	203	272	215	240	209	261	252	230	254	254	205
210	233	269	232	275	272	238	229	250	240	247	230
236	260	237	262	244	258	194	263	244	233	228	244
347	230	354	263	235	238	231	242	270	285	284	247
215	230	209	276	224	267	258	255	196	309	282	232
201	262	207	241	250	256	254	229	232	231	240	184
238	228	262	227								

OUTCROP 33 OPERATOR WOLFE
VECTOR MEAN = 243 STANDARD DEVIATION 15 DEGREES

245	259	266	230	195	240	250	197	270	271	272	232
216	235	262	245	267	213	255	258	231	190	265	217
237	240	199	261	204	239	187	190	230	269	254	237
236	288	251	220	260	236	214	247	232	231	260	227
259	282	236	291	242	217	249	240	245	227	224	259
301	247	256	234	267	249	261	224	228	197	256	240
229	230	259	229	240	250	240	224	238	205	231	232
219	237	264	260	257	239	264	241	246	245	265	202
240	240	254	253								

OUTCROP 34 OPERATOR EGGERTSON
VECTOR MEAN = 235 STANDARD DEVIATION 22 DEGREES

357	219	238	232	220	210	227	343	229	353	358	196
236	255	203	209	253	207	229	252	205	224	245	345
227	236	346	255	220	251	342	253	245	234	208	220
191	211	196	252	224	303	196	233	224	220	229	244
228	203	263	199	215	242	260	239	216	236	260	235
248	213	243	233	251	210	217	201	218	205	224	353
355	202	247	278	244	244	249	192	211	358	215	217
243	222	193	232	231	197	211	205	234	213	227	247
241	233	233	224								

OUTCROP 35 OPERATOR EGGERTSON
VECTOR MEAN = 235 STANDARD DEVIATION 20 DEGREES

229	225	211	228	224	246	247	219	226	226	221	206
221	231	211	354	254	186	231	224	232	234	232	350
210	269	265	233	236	218	350	204	252	199	191	284
267	193	209	232	226	215	200	249	218	190	230	230
245	258	249	290	223	218	198	233	245	229	184	230
252	265	220	195	221	358	213	264	254	247	343	208
230	237	220	203	223	253	249	253	339	243	271	213
224	353	184	242	251	352	194	229	252	250	191	272
251	227	246	246								

OUTCROP 36 OPERATOR WOLFE
VECTOR MEAN = 232 STANDARD DEVIATION 17 DEGREES

222	212	213	270	251	239	236	247	249	232	209	182
265	239	356	212	273	228	255	266	197	197	252	223
195	247	254	245	239	193	239	232	210	234	220	226
206	223	214	236	199	205	238	254	288	194	351	247
257	227	227	232	210	198	214	207	206	234	197	231
220	303	211	205	270	230	240	228	236	227	225	290
213	201	241	234	241	195	277	256	296	232	260	270
230	196	238	200	201	229	208	251	220	237	253	197
301	192	241	247								

OUTCROP 37 OPERATOR WOLFE
VECTOR MEAN = 229 STANDARD DEVIATION 16 DEGREES

227	236	233	237	247	215	187	229	217	232	234	358
252	270	206	274	238	227	231	223	226	228	234	201
211	216	248	233	232	229	219	218	233	256	226	254
237	229	341	225	190	187	228	348	224	206	230	225
198	277	203	218	196	328	225	256	217	218	223	222
224	233	213	210	203	197	212	221	208	265	225	226
217	225	221	206	218	252	216	219	211	290	226	252
195	262	200	225	227	239	231	246	226	224	198	228
237	299	235	253								

OUTCROP 38 OPERATOR WOLFE
VECTOR MEAN = 224 STANDARD DEVIATION 6 DEGREES

229	226	224	216	219	219	223	224	230	245	224	246
227	221	208	208	211	221	244	229	233	230	252	243
233	218	226	223	215	249	225	184	230	211	235	236
212	248	226	231	233	222	245	227	218	250	197	252
223	225	225	190	222	193	205	230	240	258	222	215
267	218	198	189	241	204	249	228	230	214	229	226
228	234	242	233	204	228	222	241	239	231	251	225
200	229	192	198	215	238	203	218	243	203	202	217
212	210	227	217								

OUTCROP 39 OPERATOR WOLFE
VECTOR MEAN = 244 STANDARD DEVIATION 15 DEGREES

282	275	250	251	259	301	251	247	256	274	237	230
264	225	246	255	216	207	245	214	229	270	262	199
222	237	233	247	185	234	240	262	280	249	237	258
254	266	262	240	237	226	227	221	266	259	279	229
236	228	263	254	260	257	201	265	234	269	257	256
311	218	246	241	279	264	188	212	259	240	206	255
239	251	233	232	225	224	230	201	276	274	187	213
270	249	258	257	245	224	257	261	232	187	237	234
193	231	250	328								

OUTCROP 40 OPERATOR EGGERTSON
VECTOR MEAN = 232 STANDARD DEVIATION 6 DEGREES

234	227	228	246	239	239	254	249	225	220	237	234
204	244	216	249	229	200	223	228	240	243	247	229
229	227	223	251	248	243	244	253	225	220	220	232
231	233	214	212	209	233	236	239	235	232	240	237
230	237	258	214	231	215	229	217	209	223	221	214
246	257	247	230	259	229	236	234	243	198	225	205
235	232	215	240	242	241	248	232	278	233	229	220
230	233	221	213	238	252	249	238	247	245	229	243
242	241	219	208								

OUTCROP 41 OPERATOR EGGERTSON
VECTOR MEAN = 223 STANDARD DEVIATION 20 DEGREES

212	359	211	236	230	248	182	213	222	237	227	237
223	237	221	237	220	192	226	240	218	199	216	210
239	249	217	219	225	225	223	224	211	222	237	200
222	223	207	195	226	230	347	221	354	225	228	205
186	227	190	193	238	214	231	219	349	212	212	226
220	218	218	213	223	227	192	219	215	224	219	200
190	227	193	184	215	352	225	223	239	233	236	219
206	191	227	260	345	238	255	246	221	223	187	356
278	271	193	198								

OUTCROP 42 OPERATOR EGGERTSON
VECTOR MEAN = 249 STANDARD DEVIATION 16 DEGREES

274	254	242	264	253	229	246	229	351	336	307	239
345	202	271	293	275	266	300	215	219	261	245	266
277	249	249	249	279	202	206	224	229	227	359	260
295	261	230	239	251	250	231	265	254	218	257	230
236	243	265	187	221	223	280	231	262	213	252	243
266	239	232	259	234	271	244	248	249	264	260	229
244	278	234	225	219	252	247	229	250	243	227	227
340	246	235	237	244	251	255	232	260	249	245	245
240	253	252	236								

OUTCROP 43 OPERATOR EGGERTSON
VECTOR MEAN = 231 STANDARD DEVIATION 17 DEGREES

224	227	242	184	210	230	269	197	233	225	225	233
199	203	209	201	236	185	233	234	222	217	195	206
229	217	215	264	256	256	226	222	262	212	240	252
251	211	276	205	214	285	212	227	236	199	205	230
230	240	190	227	218	272	220	260	225	223	261	251
254	220	263	202	196	234	280	262	235	193	273	263
255	249	256	254	222	216	185	232	227	209	293	240
210	214	272	209	256	231	211	216	250	350	191	294
275	353	181	219								

OUTCROP 44 OPERATOR WOLFE
VECTOR MEAN = 230 STANDARD DEVIATION 6 DEGREES

208	274	214	223	251	219	259	229	234	235	237	243
251	256	279	250	238	211	241	266	217	239	216	175
232	227	233	193	201	211	197	225	209	195	210	212
228	236	209	222	213	226	242	232	220	240	225	263
193	256	266	235	215	221	241	196	206	189	224	244
202	233	229	220	282	217	274	222	253	213	231	266
244	255	241	237	235	234	222	227	240	285	189	185
229	237	234	237	217	219	235	213	220	297	192	227
227	236	276	235								

OUTCROP 45 OPERATOR EGGERTSON
VECTOR MEAN = 233 STANDARD DEVIATION 17 DEGREES

270	244	244	343	198	272	239	240	235	231	230	194
204	251	252	211	275	240	349	199	271	195	220	225
254	248	274	242	211	254	240	233	233	225	191	191
244	225	230	237	222	231	231	260	238	233	240	207
229	225	359	200	207	256	218	208	235	256	212	237
245	258	199	242	232	225	247	236	232	225	225	241
269	187	228	220	220	230	203	225	215	205	228	226
203	246	248	246	239	216	221	229	266	249	260	196
212	200	279	258								

OUTCROP 46 OPERATOR EGGERTSON
VECTOR MEAN = 237 STANDARD DEVIATION 16 DEGREES

228	254	235	244	204	234	239	240	242	239	235	235
240	197	231	191	235	237	243	220	215	244	257	214
240	235	220	241	240	238	228	232	210	240	223	245
256	207	233	237	235	196	232	254	242	222	193	227
216	241	357	349	269	227	257	266	185	233	255	257
230	248	189	238	246	238	224	223	237	250	248	185
345	259	241	241	238	240	214	228	277	234	233	230
235	239	241	242	236	198	228	259	249	243	335	353
246	245	243	219								

OUTCROP 47 OPERATOR EGGERTSON
VECTOR MEAN = 234 STANDARD DEVIATION 8 DEGREES

240	226	253	244	227	227	232	261	239	216	211	231
237	232	235	237	233	264	243	278	231	227	207	216
220	241	234	230	198	234	264	258	241	230	254	266
242	240	253	245	207	196	230	238	237	252	204	228
241	223	232	220	264	230	213	225	228	230	220	247
221	264	238	225	226	223	222	250	259	210	231	240
226	202	233	231	240	235	250	255	228	257	237	182
248	248	257	205	230	248	217	224	250	239	214	260
231	228	242	231								

OUTCROP 48 OPERATOR DAVIES
VECTOR MEAN = 232 STANDARD DEVIATION 6 DEGREES

249	255	258	225	193	234	229	228	203	219	226	241
228	225	232	227	238	227	213	201	229	220	219	210
228	231	211	227	217	229	233	225	225	212	226	237
223	245	262	212	256	237	235	253	226	225	231	239
225	232	229	237	228	226	252	225	226	236	232	247
240	225	228	230	222	250	249	234	232	227	225	228
233	228	213	270	243	239	251	232	230	224	225	233
258	224	232	232	234	238	215	213	228	241	226	224
250	216										

OUTCROP 49 OPERATOR EGGERTSON
VECTOR MEAN = 233 STANDARD DEVIATION 12 DEGREES

224	231	227	223	290	221	222	229	210	231	240	246
209	204	231	224	204	204	237	219	244	227	242	216
250	272	227	220	215	224	300	255	251	245	231	226
245	255	253	192	233	277	235	236	270	236	234	200
206	199	264	259	250	258	260	244	239	253	254	215
235	272	261	222	220	238	237	198	212	248	225	255
228	238	199	226	233	228	249	256	251	284	190	227
224	210	233	236	199	242	242	210	252	214	191	215
227	269	218	220								

OUTCROP 50 OPERATOR EGGERTSON
VECTOR MEAN = 235 STANDARD DEVIATION 15 DEGREES

230	221	249	230	223	255	272	215	247	235	239	259
246	191	239	238	239	239	193	268	242	244	251	218
276	211	211	230	210	223	207	215	229	191	237	213
233	230	237	240	233	261	349	265	262	247	253	193
353	241	229	318	254	218	235	247	236	239	237	244
194	233	255	263	236	262	243	253	232	193	228	221
193	238	243	235	214	191	267	236	233	230	243	243
255	246	265	235	230	205	212	202	243	230	193	213
245	204	235	238								

OUTCROP 51 OPERATOR EGGERTSON
VECTOR MEAN = 236 STANDARD DEVIATION 16 DEGREES

219	208	356	195	219	220	218	224	229	222	210	181
197	207	199	222	199	186	253	220	226	229	223	190
188	206	222	238	211	201	209	221	216	205	203	224
208	250	270	230	238	267	273	235	253	257	235	238
230	231	204	250	239	235	250	250	243	278	247	250
232	265	237	238	290	299	250	233	232	273	234	259
272	231	234	235	257	294	269	254	250	250	244	234
234	246	254	247	253	250	249	239	243	252	254	225
213	216	216	275								

OUTCROP 52 OPERATOR EGGERTSON
VECTOR MEAN = 239 STANDARD DEVIATION 13 DEGREES

248	230	238	231	239	240	243	235	211	259	253	233
229	225	230	205	245	358	211	215	247	265	240	260
240	239	241	249	234	240	238	224	230	221	249	218
199	226	185	219	239	253	260	230	228	237	228	222
208	233	236	244	241	226	236	228	300	273	253	255
272	208	202	229	227	220	203	229	246	268	245	248
241	224	223	230	249	221	213	263	233	235	281	272
269	232	242	257	255	230	263	236	270	241	247	287
244	222	254	264								

OUTCROP 53 OPERATOR EGGERTSON
VECTOR MEAN = 23[illegible] STANDARD DEVIATION 14 DEGREES

220	266	239	214	241	235	218	235	234	201	225	221
230	212	235	265	230	227	224	236	225	258	190	265
193	233	244	235	205	242	239	236	223	190	220	215
223	219	232	212	212	234	264	237	264	272	273	263
260	194	232	199	253	235	220	227	230	234	243	203
210	175	220	202	245	228	216	235	236	220	213	195
310	283	242	273	217	212	234	215	237	179	229	231
230	232	253	213	197	195	233	251	245	219	240	191
224	307	266	218								

OUTCROP 54 OPERATOR EGGERTSON
VECTOR MEAN = 236 STANDARD DEVIATION 15 DEGREES

203	191	227	254	212	218	247	230	238	196	279	246
210	265	251	222	249	241	201	233	244	239	237	224
237	230	225	223	230	299	199	223	246	233	233	241
199	243	241	256	213	227	258	210	277	186	242	221
250	212	273	286	224	231	196	229	252	199	235	263
228	208	233	272	243	204	267	272	256	263	233	240
258	154	239	272	232	251	290	170	234	248	222	234
249	226	226	295	253	232	233	214	243	247	249	239
242	191	243	249								

OUTCROP 55 OPERATOR WOLFE
VECTOR MEAN = 223 STANDARD DEVIATION 19 DEGREES

214	206	195	214	207	203	236	252	198	206	206	197
225	213	250	223	233	220	225	211	225	204	216	223
212	217	210	208	183	220	210	221	350	229	223	268
211	212	207	210	233	203	212	229	219	209	213	221
254	230	207	201	344	216	214	229	238	196	240	192
212	201	341	344	224	281	217	232	239	206	253	253
206	215	213	262	212	212	239	200	227	192	225	209
254	224	220	200	222	213	215	249	220	200	341	135
359	233	341	273								

OUTCROP 56 OPERATOR WOLFE
VECTOR MEAN = 231 STANDARD DEVIATION 10 DEGREES

216	228	191	221	238	240	225	233	234	238	259	215
230	227	232	215	249	239	224	236	240	213	199	229
226	221	227	219	224	223	242	220	234	244	241	244
230	229	226	224	228	229	219	219	260	190	223	219
189	225	240	209	233	243	196	227	230	243	246	204
250	236	239	246	209	219	248	260	262	219	276	225
258	242	245	211	238	237	211	267	241	235	247	227
246	239	241	249	217	262	214	227	240	221	308	226
201	224	226	220								

OUTCROP 57 OPERATOR WOLFE
VECTOR MEAN = 233 STANDARD DEVIATION 11 DEGREES

221	239	235	209	227	237	203	261	218	252	243	242
229	243	263	220	273	245	230	234	220	254	255	250
228	226	241	244	252	263	259	220	224	269	215	253
228	254	245	275	212	225	257	221	220	261	223	218
237	237	241	228	234	240	263	235	219	248	243	253
230	243	214	242	253	224	228	240	246	247	250	251
238	233	231	222	237	231	232	256	199	206	247	189
257	249	215	240	223	258	261	249	241	231	258	215
222	269	222	244								

OUTCROP 58 OPERATOR WOLFE
VECTOR MEAN = 230 STANDARD DEVIATION 17 DEGREES

223	257	243	230	254	270	238	255	207	246	219	253
234	233	236	235	253	235	224	241	215	230	228	232
200	246	213	282	233	237	302	225	236	232	231	354
220	235	232	224	204	255	229	247	222	265	212	231
227	260	223	219	272	233	227	252	256	248	245	203
235	263	234	241	347	233	230	237	200	198	226	229
349	285	277	187	226	339	261	227	235	232	352	236
235	200	242	220	130	231	250	241	231	240	263	235
233	226	230									

OUTCROP 59 OPERATOR WOLFE
VECTOR MEAN = 235 STANDARD DEVIATION 15 DEGREES

260	222	216	193	239	236	214	197	204	250	234	232
240	246	261	241	232	228	217	263	255	236	234	220
271	358	222	224	132	219	343	243	235	224	243	274
231	246	231	223	249	246	250	254	207	232	275	233
239	220	218	218	214	213	190	245	240	262	262	223
220	199	240	234	225	234	235	231	296	221	215	213
228	235	232	232	230	215	250	243	228	249	234	233
205	237	232	245	238	305	211	202	222	245	225	205
242	196	242	241								

OUTCROP 60 OPERATOR WOLFE
VECTOR MEAN = 244 STANDARD DEVIATION 11 DEGREES

273	257	253	269	277	249	276	230	256	247	262	248
233	214	254	250	251	256	244	259	259	238	261	233
256	245	268	264	250	226	238	249	227	245	243	218
254	242	260	237	233	226	249	259	248	233	214	263
230	223	222	273	231	234	233	347	233	229	217	262
224	212	216	261	230	244	266	266	260	231	249	249
261	233	233	209	228	237	243	262	202	253	242	234
254	254	243	238	251	251	256	244	194	253	249	260
184	227	231	250								

OUTCROP 61 OPERATOR WOLFE
VECTOR MEAN = 247 STANDARD DEVIATION 10 DEGREES

265	279	257	254	239	264	258	232	238	234	257	226
221	243	234	233	256	279	264	248	230	267	269	289
234	253	239	258	227	238	262	257	234	252	254	253
249	243	267	263	241	240	214	239	242	271	255	253
284	241	197	246	227	247	246	246	276	245	241	231
260	262	264	266	265	255	238	259	266	255	259	234
207	233	241	244	223	252	230	232	227	234	238	231
232	238	293	231	227	245	236	242	243	235	256	234
256	243	240	238								

OUTCROP 62 OPERATOR WOLFE
VECTOR MEAN = 226 STANDARD DEVIATION 17 DEGREES

235	232	248	201	203	225	246	242	245	230	246	218
351	213	215	214	193	207	219	234	227	216	349	207
181	244	239	229	200	231	247	202	227	219	234	251
251	245	251	227	226	223	239	227	227	225	230	240
250	254	236	204	234	217	212	219	207	215	234	214
211	212	221	213	196	191	241	352	201	222	248	227
219	213	190	236	237	210	326	199	243	245	230	242
189	203	212	226	227	199	317	236	230	204	232	227
202	194	213	222								

OUTCROP 63 OPERATOR WOLFE
VECTOR MEAN = 230 STANDARD DEVIATION 23 DEGREES

246	253	244	227	228	221	197	344	242	197	287	255
225	225	182	225	187	205	225	356	251	188	187	340
234	241	239	227	248	219	217	225	208	199	215	195
204	357	233	182	200	222	231	233	229	230	272	237
233	228	227	234	218	352	358	254	199	303	233	215
190	231	220	218	213	237	236	231	212	253	198	357
341	219	243	226	201	227	220	219	222	206	212	217
229	264	217	250	194	227	223	224	221	191	270	248
240	193	191	202								

OUTCROP 64 OPERATOR WOLFE
VECTOR MEAN = 241 STANDARD DEVIATION 14 DEGREES

261	237	251	275	217	241	208	254	235	256	231	250
235	245	236	282	237	238	243	245	231	248	198	234
239	253	218	218	211	230	247	236	223	240	250	190
241	282	239	253	200	242	258	222	223	245	232	222
240	223	266	196	236	222	243	242	213	238	246	257
239	262	256	239	229	233	256	218	237	230	236	232
224	233	241	265	255	342	219	290	233	277	248	254
254	237	264	250	257	263	225	236	258	352	295	207
201	184	233	237								

OUTCROP 65 OPERATOR WOLFE
VECTOR MEAN = 233 STANDARD DEVIATION 18 DEGREES

203	234	224	245	230	235	216	193	271	185	194	215
208	227	254	220	190	344	219	220	206	224	247	205
223	264	259	184	251	233	243	200	225	218	278	241
218	226	289	242	214	227	189	287	334	245	267	219
243	209	249	259	212	227	255	233	259	342	254	228
245	230	216	258	216	285	202	226	197	222	202	197
343	218	242	200	190	275	237	230	280	244	228	239
244	235	293	232	259	210	235	239	238	200	252	187
237	219	263	220								

OUTCROP 66 OPERATOR WOLFE
VECTOR MEAN = 228 STANDARD DEVIATION 18 DEGREES

227	222	250	237	224	258	211	249	253	340	355	214
222	230	246	233	242	241	244	266	224	215	219	222
250	239	216	204	285	213	211	224	227	255	226	181
183	235	233	213	214	211	206	228	215	203	218	225
191	203	192	180	243	243	237	242	358	192	207	228
224	191	207	221	221	220	226	208	230	211	230	345
250	243	250	255	249	200	218	222	199	221	223	239
238	224	221	226	229	353	222	213	245	353	231	217
253	223	246	225								

OUTCROP 67 OPERATOR WOLFE
VECTOR MEAN = 236 STANDARD DEVIATION 18 DEGREES

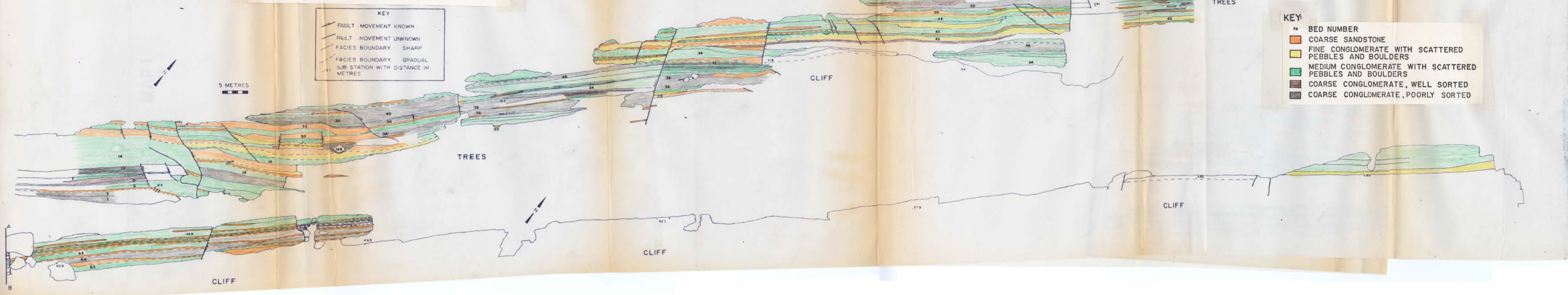
228	215	244	230	228	238	249	240	244	349	222	192
246	342	270	248	188	261	228	264	245	214	203	230
237	260	228	216	268	225	227	236	241	254	252	253
197	271	237	358	200	131	232	260	203	230	256	239
215	292	219	254	187	252	215	230	257	227	219	216
226	274	222	200	219	246	255	357	225	130	246	242
213	260	344	239	225	233	231	230	242	232	255	202
258	242	257	190	191	225	228	217	240	181	210	296
219	263	252	243								

OUTCROP 68 OPERATOR WOLFE
VECTOR MEAN = 234 STANDARD DEVIATION 17 DEGREES

208	209	235	232	241	245	273	232	264	184	257	196
225	237	357	230	237	232	201	197	214	226	197	205
250	206	224	225	241	229	226	238	190	203	210	238
197	233	324	209	263	234	193	232	264	294	206	256
213	191	204	250	187	295	271	229	192	234	272	231
231	244	237	196	255	255	236	241	236	247	246	254
222	221	263	209	240	239	235	237	201	271	248	228
240	256	235	198	276	235	288	228	261	273	230	191
220	259	252	211								

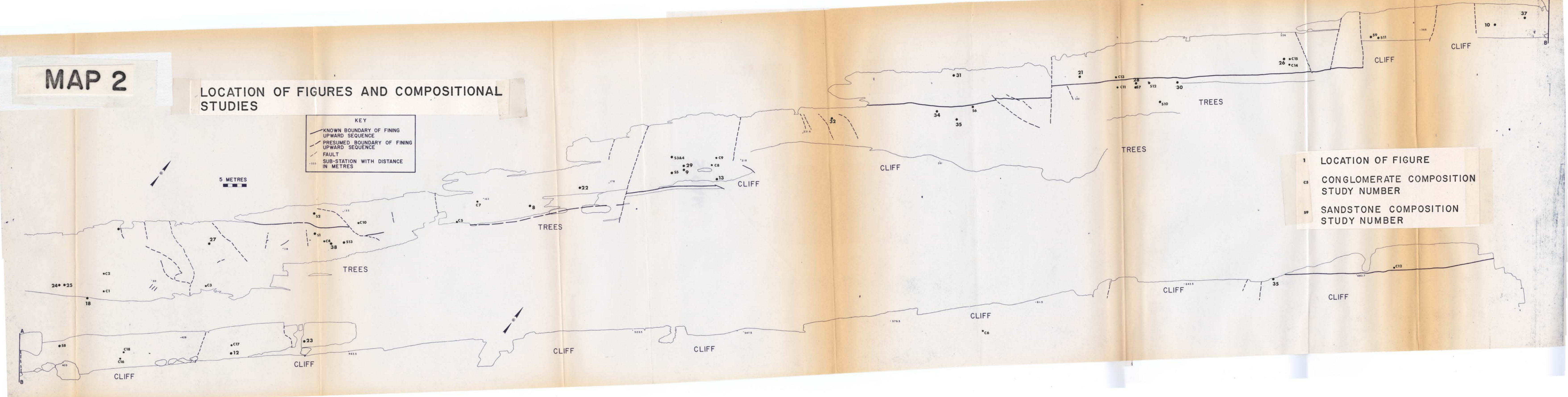
MAP I

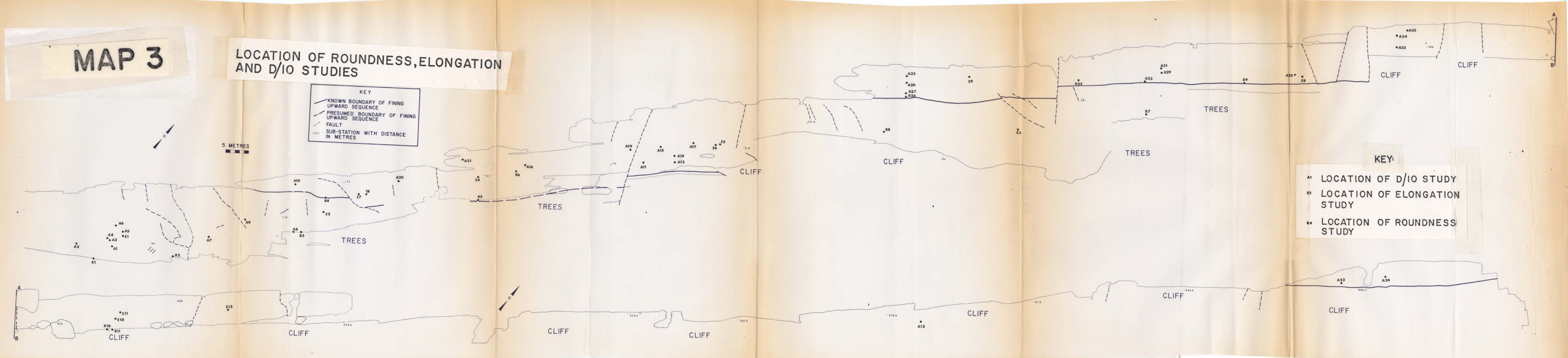
PLAN VIEW OF THE GENERAL GEOLOGY OF HORIZON 3



MAP 2

LOCATION OF FIGURES AND COMPOSITIONAL STUDIES




MAP 3
LOCATION OF ROUNDNESS, ELONGATION AND D/IO STUDIES
KEY
KNOWN BOUNDARY OF FINING UPWARD SEQUENCE
PRESUMED BOUNDARY OF FINING UPWARD SEQUENCE
FAULT
SUB-STATION WITH DISTANCE IN METRES
5 METRES
TREES
CLIFF
KEY:
A1 LOCATION OF D/IO STUDY
E3 LOCATION OF ELONGATION STUDY
R4 LOCATION OF ROUNDNESS STUDY
A
B

MAP 4

LOCATION OF IMBRICATION AND ORIENTATION STUDIES