non-undulatory quartz increases markedly between the Lower and Middle Freda and remains high thereafter. Based on the relative abundance of the three types of quartz, it would seem that the Middle Freda represents a period in which the greatest stress was placed on the sedimentary assemblage as is shown by the low content of polycrystalline quartz and the increase in unstrained quartz. The average grain size is fine and few rock fragments occur. This all seems to indicate prolonged weathering and low energy conditions.

Textural diagrams (figs. 63-68) utilizing mean size, skewness, standard deviation and kurtosis were constructed in the manner proposed by Friedman (1961, 1962). The purpose of the skewness versus kurtosis plot is to evaluate deviation from log-normal distributions, which may help distinguish between beach and river sands. The term "beach" is taken to stand for all very shallow water marine or lacustrine deposits. Those samples falling in the negatively skewed portion of the diagram are considered to be "beach" deposits, in other words, sands, which have a finer mode than mean. The skewness versus standard deviation plot involves a comparison of the asymmetry of the distribution with the

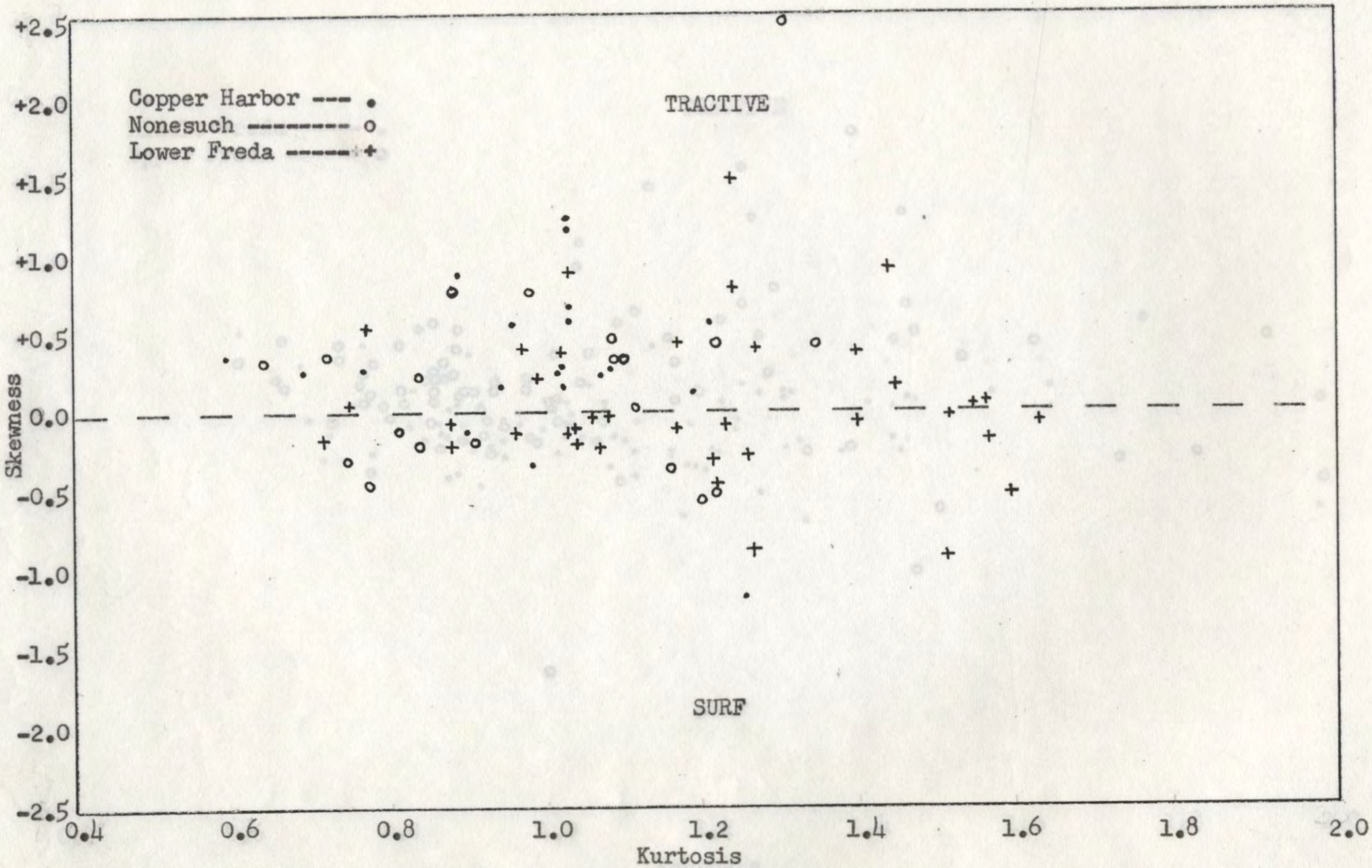

Figure 63. Plot of skewness and kurtosis using phi scale for beach and river sands.

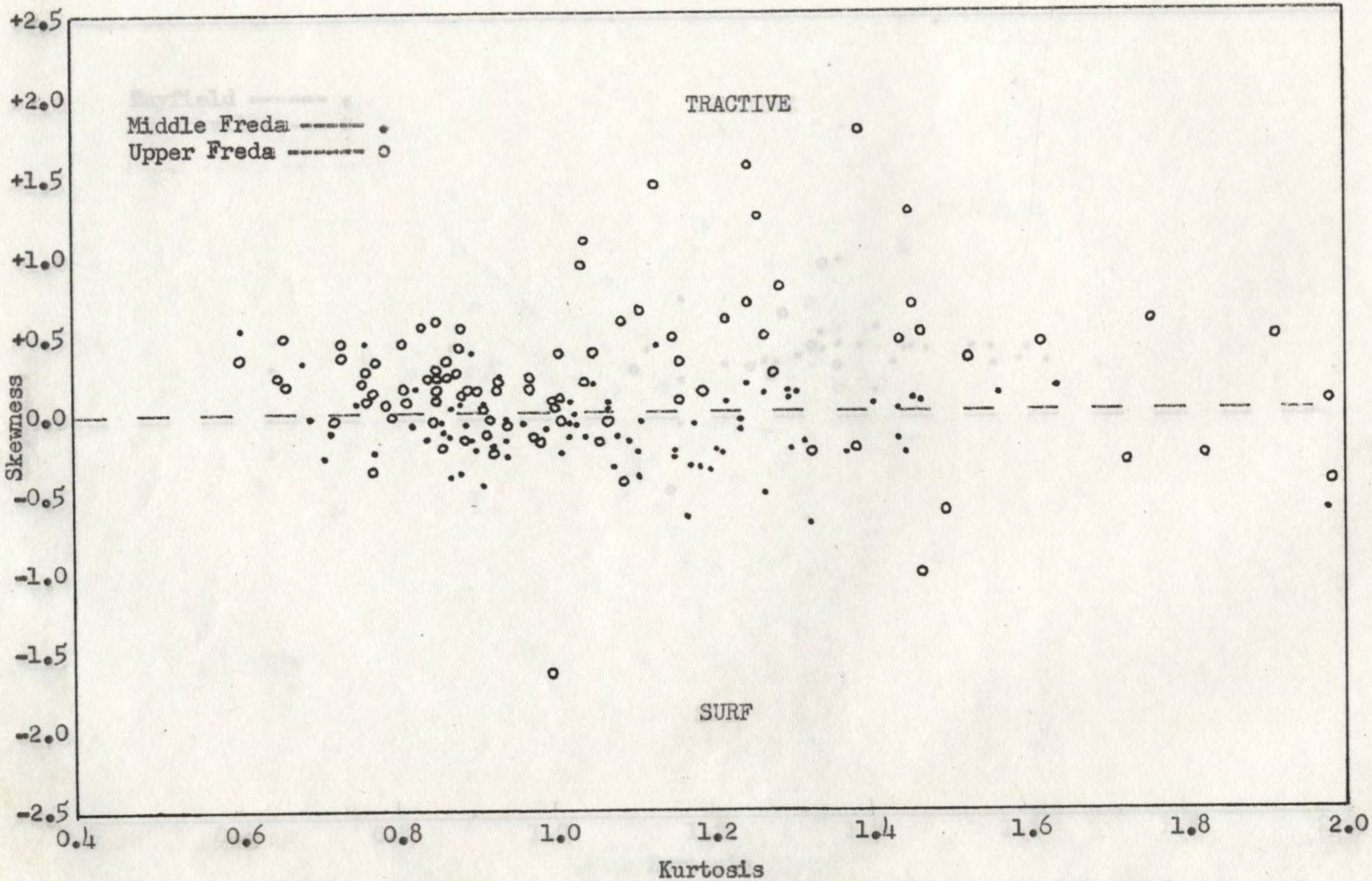

Figure 64. Plot of skewness and kurtosis, using phi scale, for beach and river sands.

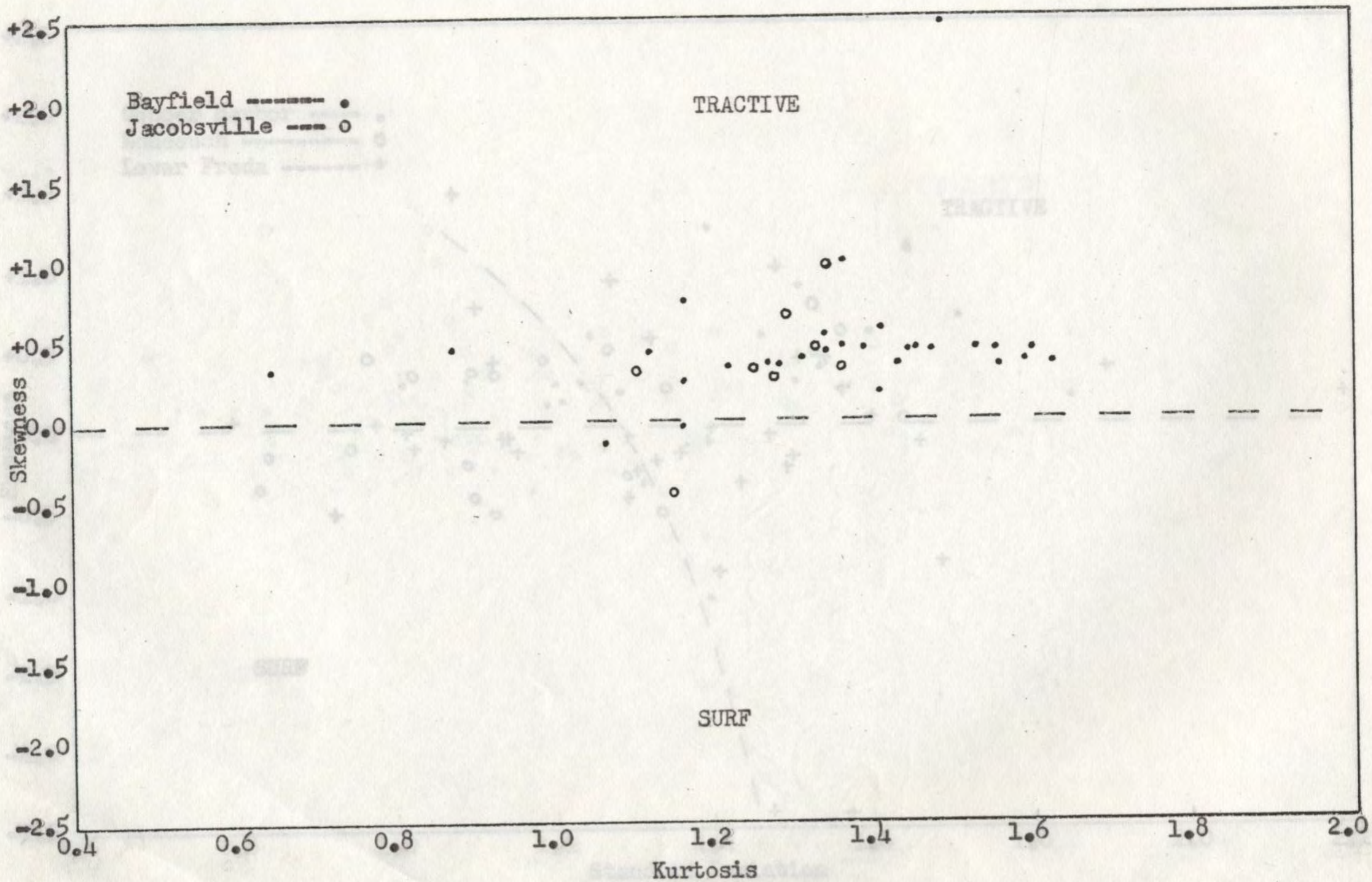

Figure 65. Plot of skewness and kurtosis, using phi scale, for beach and river sands.

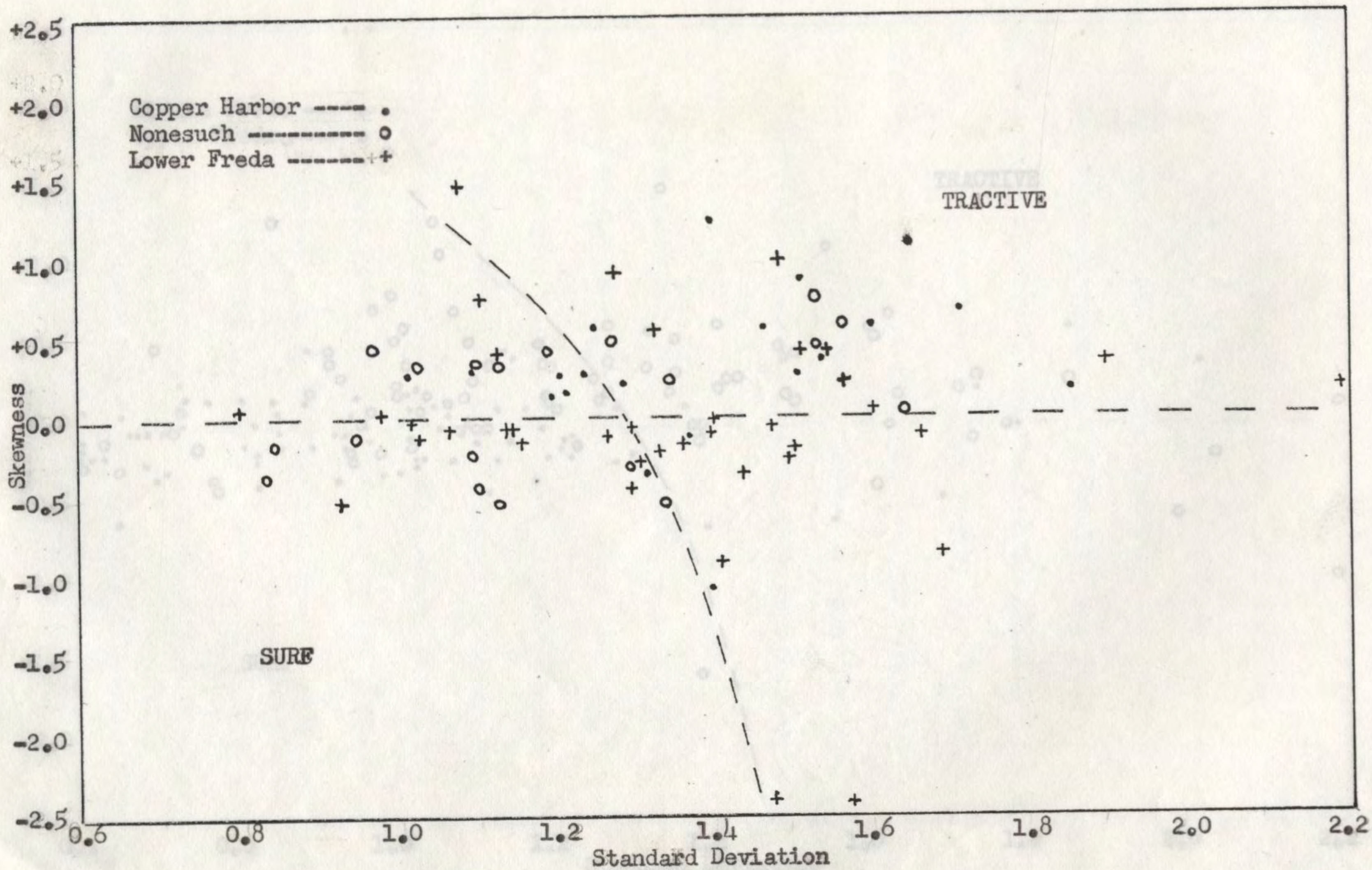

Figure 66. Plot of skewness and standard deviation, using phi scale, for beach and river sands.

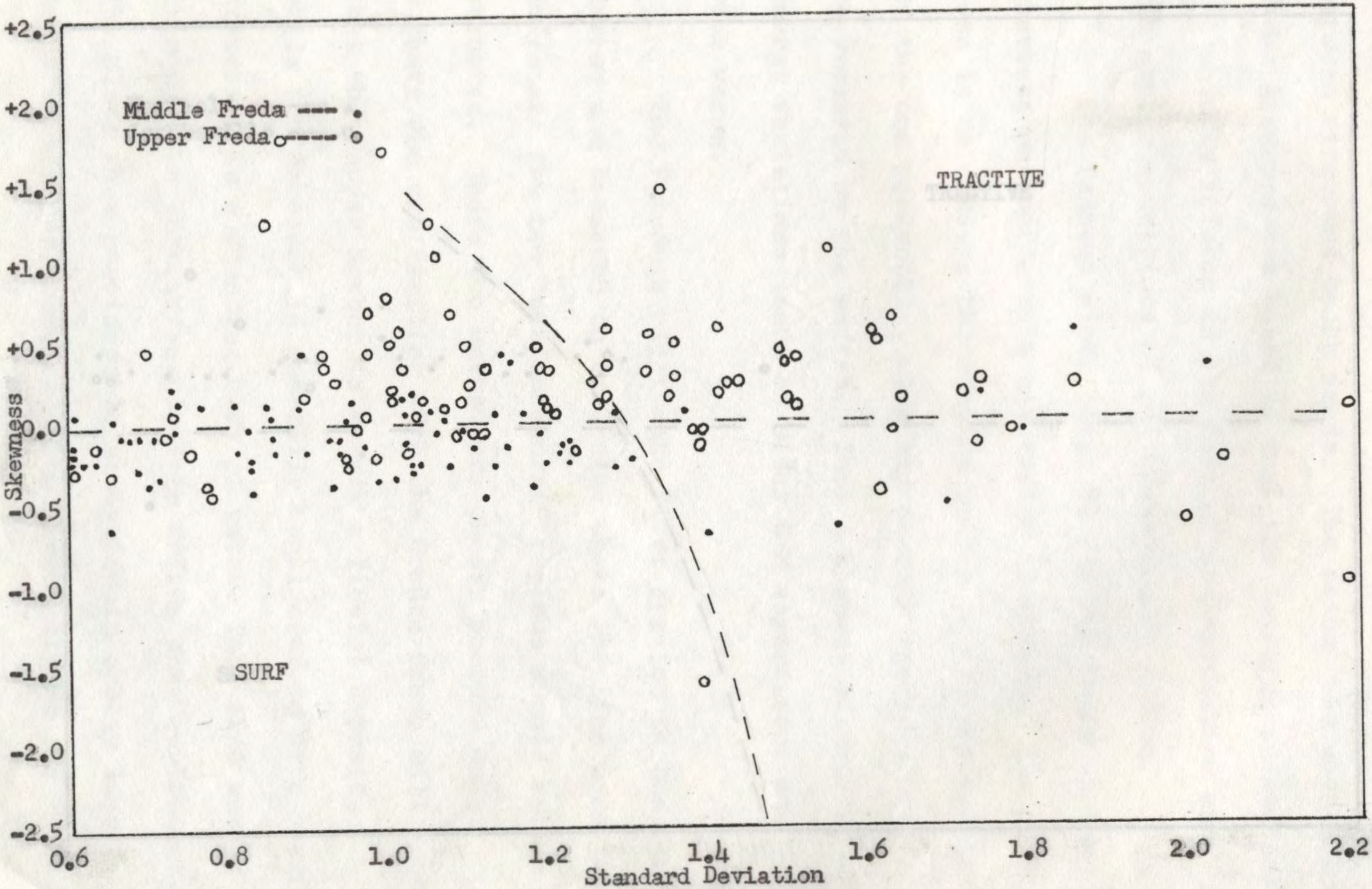

Figure 67. Plot of skewness and standard deviation, using phi scale, for beach and river sands.

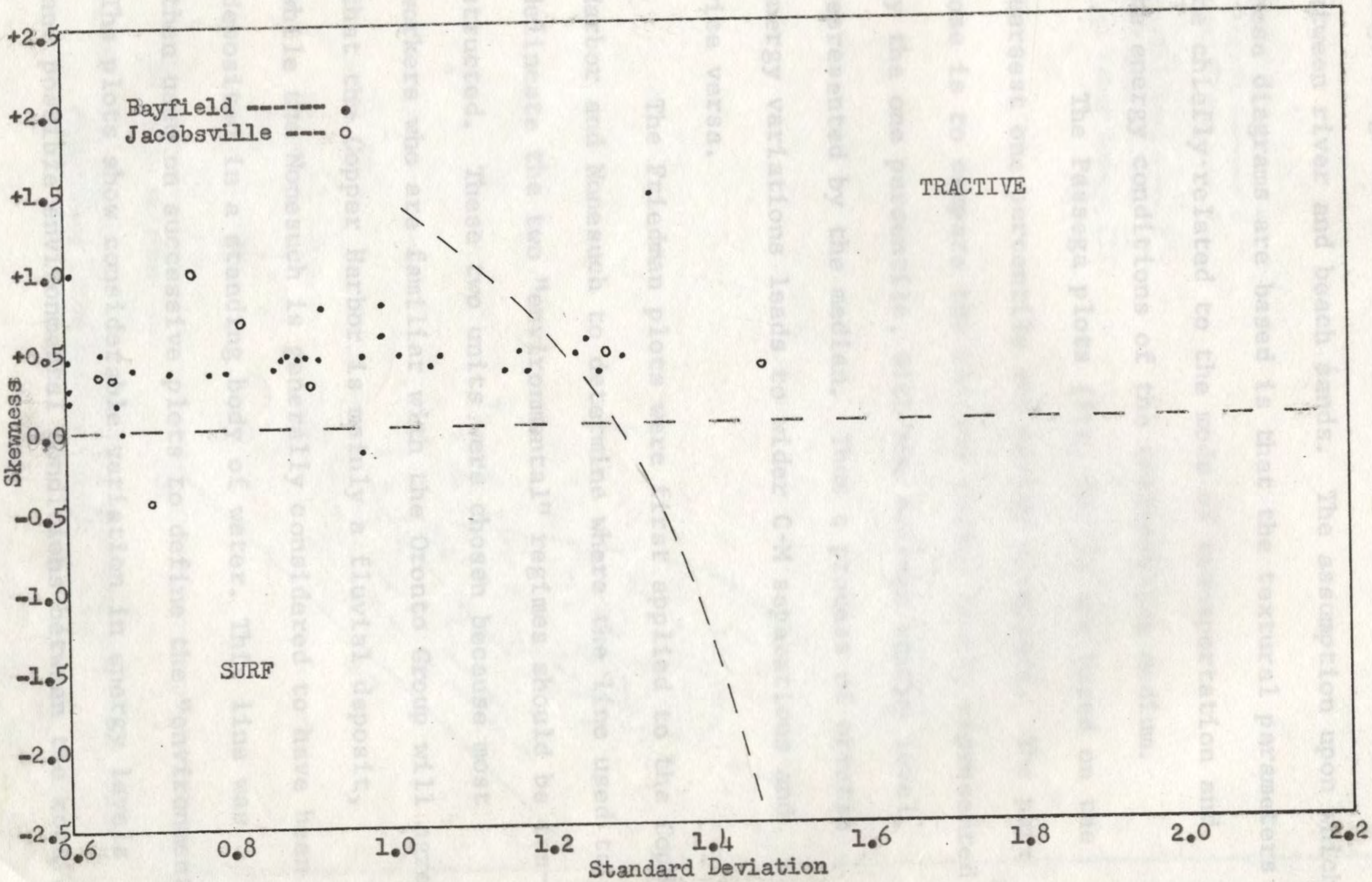

Figure 68. Plot of skewness and standard deviation, using phi scale, for beach and river sands.

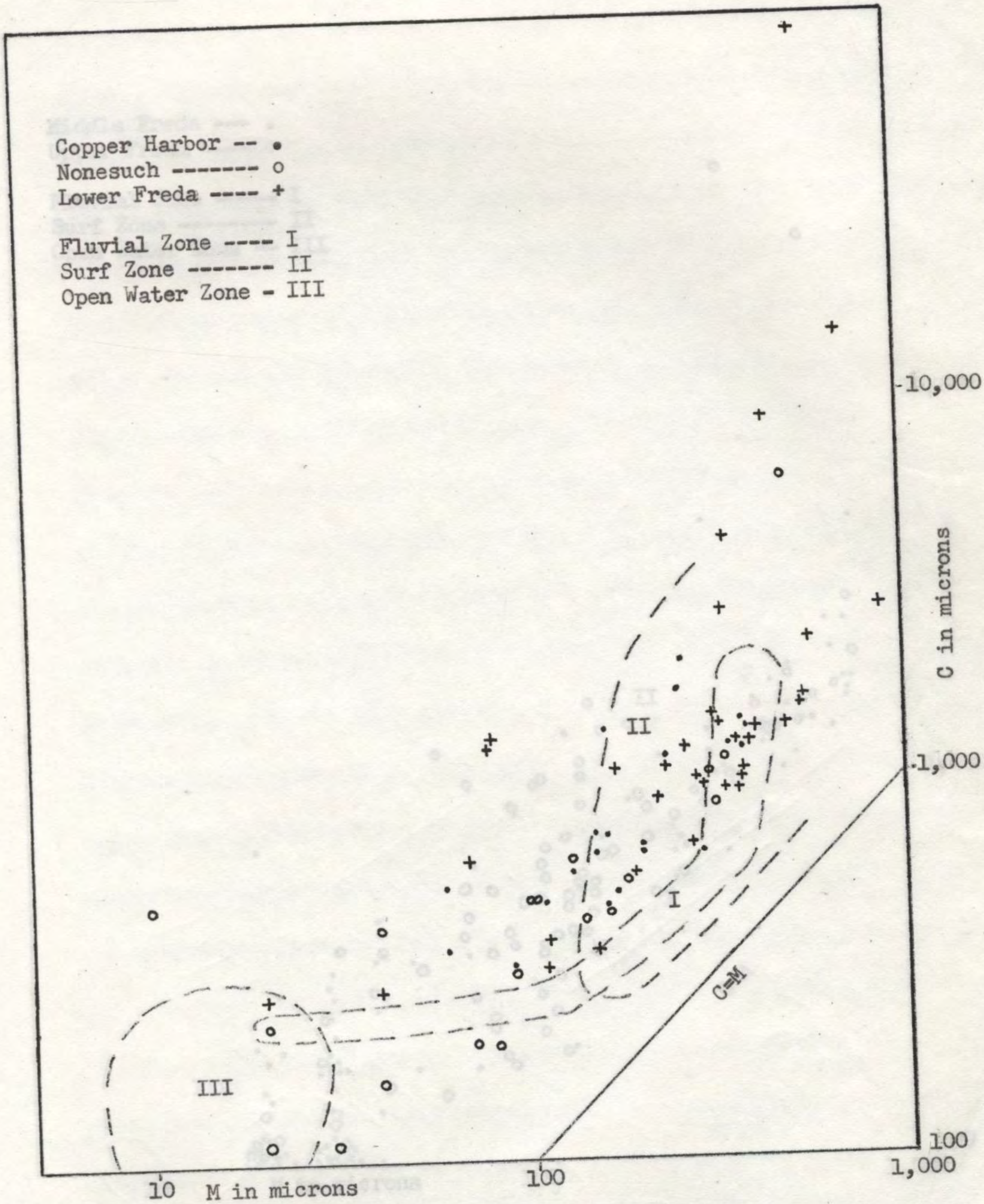

Figure 69. C-M diagram of Copper Harbor, Nonesuch, and Lower Freda sandstones; after Passega (1957)

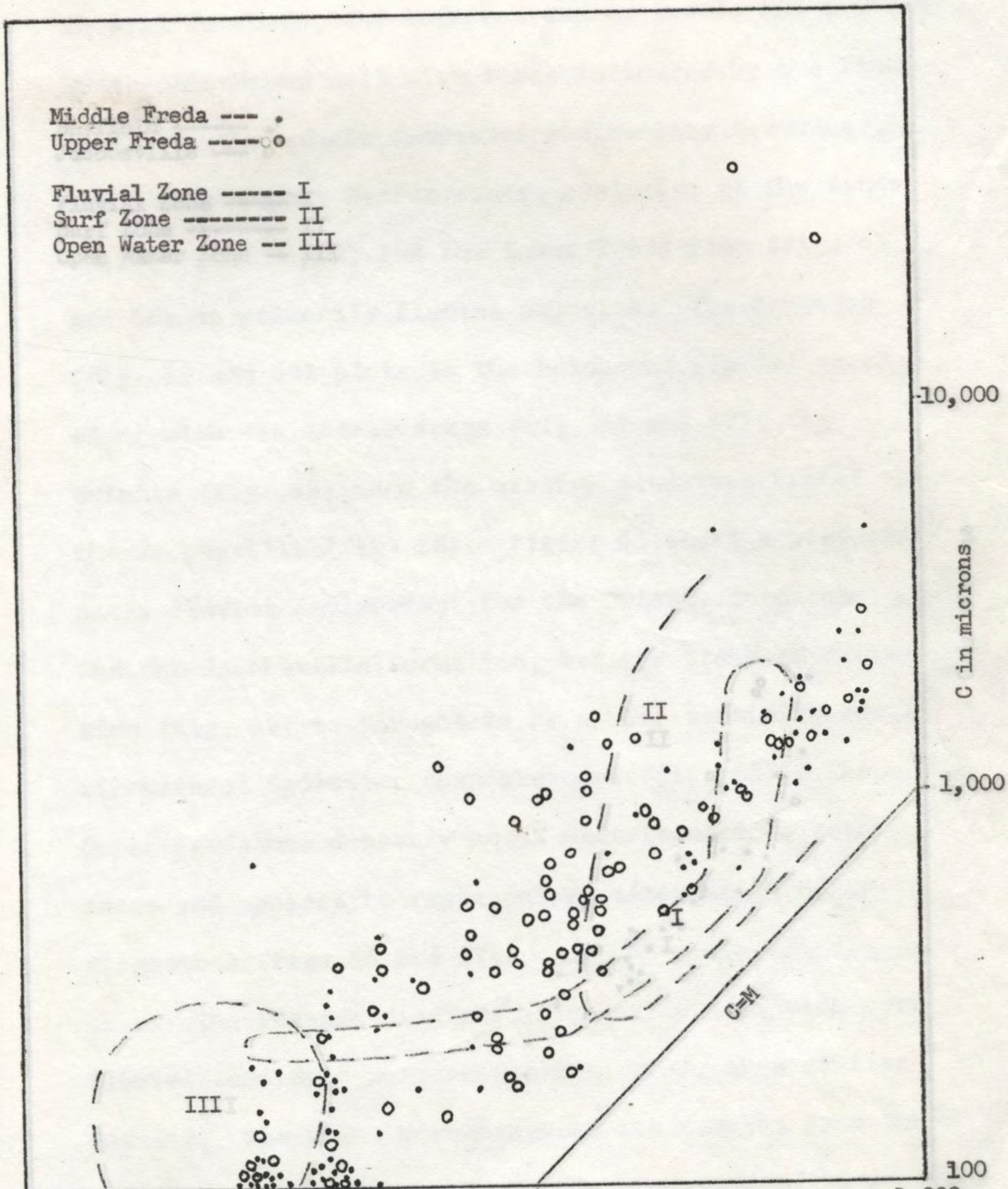

Figure 70. C-M diagram of Middle and Upper Freda sandstones; after Passega (1957)

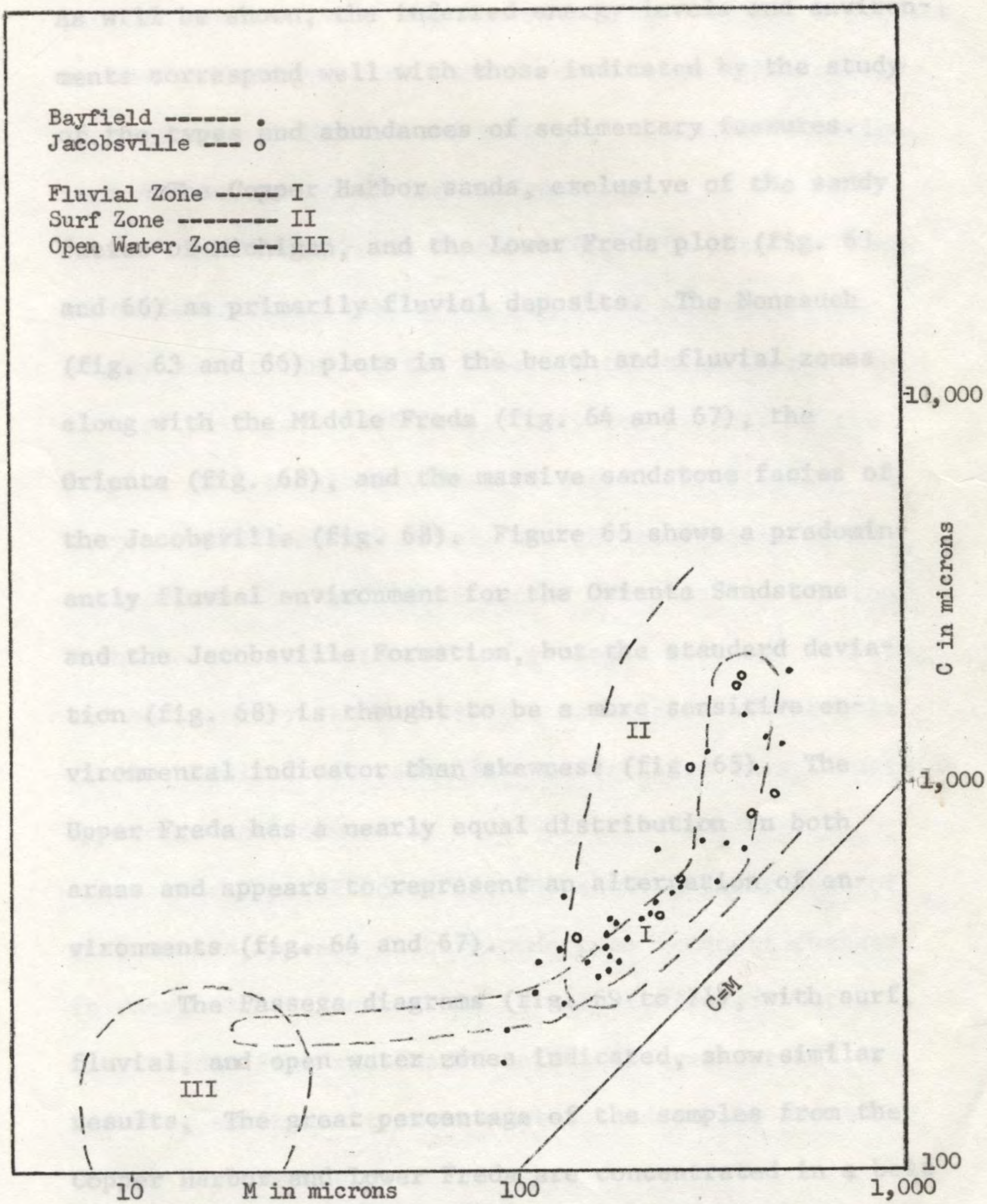

Figure 71. C-M diagram of Bayfield and Jacobsville sandstones; after Passega (1957)

As will be shown, the inferred energy levels and environments correspond well with those indicated by the study of the types and abundances of sedimentary features.

The Copper Harbor sands, exclusive of the sandy facies of Michigan, and the Lower Freda plot (fig. 63 and 66) as primarily fluvial deposits. The Nonesuch (fig. 63 and 66) plots in the beach and fluvial zones along with the Middle Freda (fig. 64 and 67), the Orienta (fig. 68), and the massive sandstone facies of the Jacobsville (fig. 68). Figure 65 shows a predominantly fluvial environment for the Orienta Sandstone and the Jacobsville Formation, but the standard deviation (fig. 68) is thought to be a more sensitive environmental indicator than skewness (fig. 65). The Upper Freda has a nearly equal distribution in both areas and appears to represent an alternation of environments (fig. 64 and 67).

The Passega diagrams (fig. 69 to 71), with surf, fluvial, and open water zones indicated, show similar results. The great percentage of the samples from the Copper Harbor and Lower Freda are concentrated in a belt parallel to the C-M line in the portion of the diagram representing both surf and fluvial conditions. Comparison with the Friedman plots leads one to select the fluvial environment. The Nonesuch (fig. 69) has a greater scatter and ranges from surf to open water. Low energy is obviously indicated and strongly suggests deposition in a marine or lacustrine environment.

The Middle Freda samples (fig. 70) have two areas of concentration, one in the region of extremely low energy conditions and the other in the high energy portion of Passega's surf zone. Only ten percent of the samples fall within the fluvial zone. The diagrams of course reflect energy levels and the assignment of an environment to a unit is a second order interpretation. With due consideration of the geologic setting, lithology, and sedimentary structures, the deposition of the bulk of the Middle Freda seems to have occurred in a lacustrine or marine environment.

The Upper Freda (fig. 70) shows a great deal of scatter and appears to have undergone frequent changes in energy conditions. This is also reflected in the interbedded fine and coarse units. A transitional or mud flat environment seems most suited to the character of the Upper Freda.

The Bayfield Group and Jacobsville Formation plot very similarly (fig. 71), and most samples lie within the region common to both the fluvial and surf zones. Based on the Friedman plots, it is probable that at least a portion of the two units is non-fluvial. The conclusion that both fluvial and surf conditions existed seems probable.

The analysis of sedimentary features was performed by constructing a table of frequency for the occurrence of various types of stratification and sedimentary structures (Table 19). This was then compared with Picard's (1966) listing of the frequencies of like features in modern environments (Table 20) used by him to help interpret Permian-Triassic red beds very similar to the Freda. Picard's listing of major, characteristic features of certain environments is given in Table 21. Using this approach, the Copper Harbor and Lower Freda again appear to be fluvial. The Nonesuch corresponds to a shallow water, open marine (?) environment. The characteristics of the Middle Freda suggest it may be a littoral deposit, but some features such as ripple stratification suit a tidal flat complex more closely. Because this unit has alternating horizontally-laminated and ripple-stratified packets, especially in the lower portion, an alternation of hydrodynamic conditions may

TABLE 19

Relative abundance of sedimentary structures in units of the Upper Keweenawan; (C.H., Copper Harbor; N., Nonesuch; L.F., Lower Freda; M.F., Middle Freda; U.F., Upper Freda; B., Bayfield; J., Jacobsville; - T, trace; R, rare; C, common; A, abundant)

Sedimentary Features	C. H.	N.	L. F.	M. F.	U. F.	B.	J.
Trough Cross-stratification	T-R		R	C-A	C-A	C	A
Planar Cross-stratification	T	T	C	C-A	C-A	C-A	C-A
Ripple Stratification		T	T	C	C		
Horizontal Stratification	C	A	C	C	C-A	C	C
Graded Bedding		T					
Disturbed Bedding		T	T	C-A	C-A	C	C
Sublenticular Lamination		R		R	R	T	T
Asymmetrical Ripple Mark	T	T	T-R	C	C	R-C	R-C
Symmetrical Ripple Mark		T		T-R	R		
Rib-and-Furrow		C-A		T-R	C		C
Current Lineation	T	R	T-R	C	C	C	
Rill Mark					T	R	
Shrinkage Crack	T-R	R	T	T	T-R	T	T-R
Channels	R-C		R		R-C	R	R
Mud-pebble Conglomerate		T	T	T-R	R-C	R	R-C
Flute Cast		T			T		
Clastic Dike					T	T	T-R
Heavy Mineral Concentration						C	
Interference Ripple					T	T	
Giant Asymmetrical Ripple						T	

TABLE 20

Guide to depositional environments
(refer to TABLE 19 for abbreviations)

Bedding Types, Sedimentary Structures, Other Features	Depositional Environments				
	Fluvial	Transi-tional	Tidal Flat Complex	Littoral	Shallow-water, Open Marine
Trough Cross-strata	C-A		C	C-A	C-A
Planar Cross-strata	C		R	C	C
Ripple-stratification	C-A	C	R-C	R	R
Horizontal Strata	C		C	C	C
Graded Bedding	R-C	R	R	R	R
Disturbed Bedding	R	C	C-A	C	R
Sublenticular Lam.					
Asym. Ripple Mark	R-C	C	A	C	R-C
Sym. Ripple Mark	R	R	C	R-C	C
Interference Ripple	R	R	C	R	
Giant, Asym. Ripple	R	--	R		--
Rib-and-Furrow	R-C	R-C	C	C	C
Current Lineation	R-C		R-C	R-C	R-C
Rill Mark			R	R	
Shrinkage Crack	C	C-A	R-C	R	R
Channel	C (large)	R-C	C (small)	R-C	R(small)
Mud-pebble Cong.	R-C	C	C	R	R
Flute Cast	R	--	--	R	R

TABLE 21

Major, characteristic features of environments
(minor but useful elements in parentheses)

Environment	Stratification	Structures	Texture	External and lithologic features: shape and size
Fluvial	high angle cross-strata ripple-stratification horizontal stratification (graded bedding)	shrinkage crack (rain drop impression) (giant, asymmetrical ripple mark)	poor sorting poor rounding	large channels with sharply disconformable bases; shoestring, prism, small-medium
Transitional	ripple-stratification disturbed bedding sublenticular lamination marsh lamination	shrinkage crack burrowed structure asymmetrical ripple mark (flat-topped ripple mark) (rain drop impression) (salt cast)	poor sorting poor-fair rounding	variable basal contacts, mud-pebble conglomerate; shoestring, prism small
Tidal Flat Complex	trough cross-strata horizontal stratification disturbed bedding sublenticular lamination (ripple stratification)	common, diverse ripple mark, "rib-and-furrow", burrowed structure, (flat-topped ripple mark), (rill mark) (giant, asymmetrical ripple mark) (shrinkage crack) (rain drop impression) (salt cast)	fair sorting fair rounding	small channels with disconformable bases mud-pebble conglomerate; prism, tabular blanket small
Littoral	low-angle cross-strata disturbed bedding horizontal stratification	asymmetrical ripple mark "rib-and-furrow" burrowed structure (symmetrical ripple mark) (flat-topped ripple mark)	good-excellent sorting good rounding "coarse" grains	parallel and transitional basal contacts, concentration of heavy minerals tabular, blanket, small
Shallow-water Open Marine	low-angle cross-strata horizontal stratification (graded bedding)	symmetrical ripple mark "rib-and-furrow" burrowed structure (asymmetrical ripple mark)	good-excellent sorting good rounding	very small channels with parallel to slightly disconformable bases, tabular blanket, small-large

have occurred. The near absence of channels argues strongly against a fluvial environment. Because of the fine-grained nature of the rocks and the lack of channeling, the source area must have been low and/or distance at this time.

The Upper Freda corresponds most closely to a tidal flat situation. The increased coarseness and apparent regression of the lake or sea must indicate renewed uplift in the source area or a drop in base level. More vigorous streams transported pebble size material and channeling became more common.

The Bayfield Group and Jacobsville Formation appear to be the products of more than one depositional environment. The heavy mineral concentrations and parallel transitional contacts in some areas are typical of littoral deposits, but on the other hand, giant asymmetrical ripple marks, channels and mud-pebble conglomerates are characteristic of fluvial or mudflat conditions and occur most commonly on the lower part of Orienta Sandstone while the heavy mineral concentrations and other features more characteristic of littoral conditions occur stratigraphically higher. The four facies of the Jacobsville defined by Hamblin (1958) probably represent these varying environments. The lower portion of the Bayfield in contact with the Freda, is considered fluvial, but it becomes more typically littoral upward in the section.

When comparing the data of this paper with Table 21 it is noteworthy that the textures do not agree entirely with those considered typical of the environments to which the various units of the Upper Keweenawan were assigned. For example, the Upper Keweenawan shows relatively poor sorting and rounding: this is probably due to rapid deposition and burial of the sediments, without extensive attrition.

The question of lacustrine versus marine deposition has been ignored in past discussions of the environment of deposition of these rocks. Anything that was not considered fluvial, and very few were not, was automatically termed lacustrine. One can not help but wonder if such an environmental picture would have been so readily created and accepted if this sequence of rocks was not exposed in the vicinity of Lake Superior or if it were not predominantly red-colored. If the similar and possibly correlative clastic sequence found sourthward along the Mid-continent Gravity High were exposed in Nebraska, would the non-fluvial deposits be so readily assigned a lacustrine origin? The large areal extent of the Oronto Group over 41,000 square miles (Irving, 1883) and with possible extension along the Mid-continent Gravity High, requires a very vast lake or a great series of lakes if "lacustrine deposits" occur throughout its extent. The data presented here cannot be utilized to distinguish between lacustrine and marine environments. Even though marine conditions would require a much greater transgression of the sea in the late Precambrian than is recognized at present, such a possibility should not be disregarded. In the absence of ecologically-diagnostic fossils, the available evidence is entirely inconclusive.

Correlation and Age

The Jacobsville Formation and Bayfield Group appear to be correlative units. Their great similarity is shown by heavy mineral suites, bulk mineralogy, sedimentary features and paleomagnetic measurements. The question of the age of these two units and their relationship to the Upper Freda is less clear, but evidence strongly suggests a conformable contact between the Freda Sandstone and the Bayfield Group. The mineralogy, heavy mineral suites, sedimentary features, textural characters and paleomagnetism show gradual changes between the two units. Close examination of the two areas, the South Fork of Fish Creek and the Middle River;(fig. 2, p. 5) where the contact is intermittantly exposed show no abrupt termination or introduction of any new mineralogical constituent or sedimentological characteristic. Based on the studies applied to these rocks, especially along the contact zones, it is felt strongly that the Bayfield and Jacobsville are late Keweenawan in age.

SUMMARY OF CONCLUSIONS

This study has led to a number of conclusions that are relevant to the understanding of the geology of the Upper Keweenawan and that may apply in similar studies elsewhere. The conclusions are summarized below.

1. Based on the studies of heavy minerals, sedimentary features, paleomagnetism and reinterpretation of structural relations, the terms Eileen and Amnicon are discarded as valid formational names as was suggested by Tyler et al., (1940). The Eileen strata are placed in the Orienta Formation (Bayfield Group) and the Amnicon is referred to the Upper Freda.

2. The conglomerates and sandstones of the Oronto Group reflect gradual changes in provenance. The Middle Keweenawan lavas contributed the bulk of the clastic material to the Copper Harbor Conglomerate and Nonesuch Formation and the pre-Keweenawan complex was the major contributor to the Freda Sandstone.

3. Grain size exerts a major control on composition and is especially important in causing lateral variation in composition.

4. Lateral variation is not solely a function of grain size but may as on the Bad River reflect local Middle Keweenawan sources which persisted possibly due to tectonic activity. These variations are best shown by the conglomerates.

5. Textural parameters, especially standard deviation, can be used to infer energy levels and possible environments of deposition, but they should not be used without independent supporting evidence, such as sedimentary structures, and preferably fossils.

6. The Upper Keweenawan sedimentary rocks were deposited in a large, rapidly subsiding basin by a combination of fluvial and lacustrine or marine processes.

7. The paleocurrent pattern changes markedly both

vertically and laterally, but does tend to support a southerly or southeasterly source, with transport both toward and parallel to the axis of the basin.

8. The Jacobsville Formation and Bayfield Group are considered correlative and should be placed in the Upper Keweenawan, as no evidence was found which indicates an unconformity between the Freda Sandstone and the Bayfield Group.

9. The reliability of sedimentary features used to determine paleocurrent patterns appears to decrease markedly as the dip of the master strata increases. This is indicated when comparing the Upper Freda data at Clinton Point (dips 20-35 degrees) with that in the Oronto Bay area (dips 60-80 degrees). The problem is primarily related to the quality of exposure of trough cross-strata. It is extremely difficult in areas of high dip to correctly ascertain the true orientation of the troughs.

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APPENDIX

Code Names for Vector Analysis

Computer Printout of R-Mode

MAFIC,	Mafic volcanic clasts
SILIC,	Silicic volcanic clasts
SEDS,	Sedimentary clasts
META,	Metamorphic clasts
UNQTZ,	Unstrained quartz
STQTZ,	Strained quartz
POLY,	Polycrystalline quartz
KSPAR,	Potassium Feldspar
PLAGIO,	Plagioclase
EPID,	Epidote
OPAQUE,	Opaque minerals, (ilmenite, magnetite, hematite, etc.)
OTHER,	Other grains (garnet, staurolite, tourmaline, etc.)

OTT ORONTO HITE, PERCENT GRAINS, R MODE QMODE

COPPER HARBOR CONGLOMERATE

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	3.516	29.3	29.3	31.0	31.0
2	2.208	18.4	47.7	19.4	50.4
3	1.645	13.7	61.4	14.5	64.9
4	1.243	10.4	71.8	10.9	75.8
5	1.018	8.5	80.3	9.0	84.8
6	.799	6.7	86.9	7.0	91.8
7	.518	4.3	91.2	4.6	96.4
8	.411	3.4	94.7	3.6	100.0
9	.341	2.8	97.5		
10	.196	1.6	99.1		
11	.103	.9	100.0		
12	.000	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 11.360

REORDERED OBLIQUE PROJECTION MATRIX -- R MODE   COPPER HARBOR CONGLOMERATE

NAME	INDEX	KSPAR	POLY	SILIC	MAFIC	EPID	PLAGIO	SEDS	OPAQUE
	INDEX	8	7	2	1	11	9	3	10
KSPAR	8	1.000	.000	.000	.000	.000	.000	.000	.000
POLY	7	.000	1.000	.000	.000	.000	.000	.000	.000
META	4	.326	.704	.549	.426	.049	.073	.312	-.231
SILIC	2	.000	.000	1.000	.000	.000	.000	.000	.000
OTHER	12	-.361	-.155	.449	.296	.344	-.108	-.008	.343
STQTZ	6	-.085	-.449	-.941	-.777	.208	-.251	.275	-.237
MAFIC	1	.000	.000	.000	1.000	.000	.000	.000	.000
EPID	11	.000	.000	.000	.000	1.000	.000	.000	.000
PLAGIO	9	.000	.000	.000	.000	.000	1.000	.000	.000
SEDS	3	.000	.000	.000	.000	.000	.000	1.000	.000
OPAQUE	10	.000	.000	.000	.000	.000	.000	.000	1.000
UNQTZ	5	-.559	.282	-.162	-.630	-.427	-.069	-.657	-.808

DOTT ORONTO HITE, PERCENT GRAINS, RMODE Q MODE NONESUCH FORMATION

TABLE OF POSITIVE EIGENVALUES

		PERCENT OF COMMUNALITY OVER			
NO.	EIGENVALJE	ALL (12) FACTORS		8 ROTATED FACTORS	
1	4.532	37.8	37.8	39.3	39.3
2	2.314	19.3	57.1	20.0	59.3
3	1.353	11.3	68.3	11.7	71.0
4	1.145	9.5	77.9	9.9	81.0
5	1.007	8.4	86.3	8.7	89.7
6	.473	3.9	90.2	4.1	93.8
7	.408	3.4	93.6	3.5	97.3
8	.309	2.6	96.2	2.7	100.0
9	.199	1.7	97.8		
10	.158	1.3	99.2		
11	.099	.8	100.0		
12	.002	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 11.543

REORDERED OBLIQUE PROJECTION MATRIX — R MODE NONESUCH FORMATION

NAME	INDEX	MAFIC 1	KSPAR 8	POLY 7	EPID 11	PLAGIO 9	OTHER 12	OPAQUE 10	SEDS 3
MAFIC	1	1.000	.000	.000	.000	.000	.000	.000	.000
UNQTZ	5	-.635	-.065	-.295	-.277	.181	-.391	-.212	-.404
KSPAR	8	.000	1.000	.000	.000	.000	.000	.000	.000
POLY	7	.000	.000	1.000	.000	.000	.000	.000	.000
EPID	11	.000	.000	.000	1.000	.000	.000	.000	.000
PLAGIO	9	.000	.000	.000	.000	1.000	.000	.000	.000
STQTZ	6	-.490	-.198	-.349	-.418	.604	-.260	-.257	-.450
SILIC	2	.154	-.188	.397	.520	-.886	.177	-.101	.384
OTHER	12	.000	.000	.000	.000	.000	1.000	.000	.000
OPAQUE	10	.000	.000	.000	.000	.000	.000	1.000	.000
SEDS	3	.000	.000	.000	.000	.000	.000	.000	1.000
META	4	-.093	.240	.309	.280	-.306	.314	.143	.927

DOTT ORONTO HITE, PERCENT GRAINS, R MODE Q MODE LOWER FREDA

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	4.389	36.6	36.6	38.8	38.8
2	1.766	14.7	51.3	15.6	54.4
3	1.509	12.6	63.9	13.4	67.8
4	1.085	9.0	72.9	9.6	77.4
5	.948	7.9	80.8	8.4	85.8
6	.698	5.8	86.6	6.2	91.9
7	.599	5.0	91.6	5.3	97.2
8	.312	2.6	94.2	2.8	100.0
9	.290	2.4	96.6		
10	.233	1.9	98.6		
11	.172	1.4	100.0		
12	.000	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 11.305

REORDERED OBLIQUE PROJECTION MATRIX -- R MODE LOWER FREDA SANDSTONE

NAME	INDEX	STQTZ 6	POLY 7	KSPAR 8	OTHER 12	META 4	PLAGIO 9	EPID 11	SILIC 2
STQTZ	6	1.000	.000	.000	.000	.000	.000	.000	.000
MAFIC	1	-.680	-.066	.001	.016	-.050	.161	.168	.397
OPAQUE	10	-.818	-.576	-.328	-.360	-.333	.062	.094	-.025
POLY	7	.000	1.000	.000	.000	.000	.000	.000	.000
SEDS	3	-.114	.599	-.173	.168	.242	.126	-.071	.506
KSPAR	8	.000	.000	1.000	.000	.000	.000	.000	.000
OTHER	12	.000	.000	.000	1.000	.000	.000	.000	.000
META	4	.000	.000	.000	.000	1.000	.000	.000	.000
PLAGIO	9	.000	.000	.000	.000	.000	1.000	.000	.000
EPID	11	.000	.000	.000	.000	.000	.000	1.000	.000
SILIC	2	.000	.000	.000	.000	.000	.000	.000	1.000
UNQTZ	5	.397	-.155	-.108	.064	.167	-.307	-.295	-.850

DOTT ORONTO HITE, PERCENT GRAINS, R MODE Q MODE MIDDLE FREDA

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	3.106	25.9	25.9	27.7	27.7
2	2.477	20.6	46.5	22.1	49.8
3	1.725	14.4	60.9	15.4	65.2
4	1.093	9.1	70.0	9.7	74.9
5	.999	8.3	78.3	8.9	83.8
6	.796	6.6	85.0	7.1	90.9
7	.594	5.0	89.9	5.3	96.2
8	.425	3.5	93.5	3.8	100.0
9	.363	3.0	96.5		
10	.305	2.5	99.0		
11	.113	.9	100.0		
12	.002	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 11.216

REORDERED OBLIQUE PROJECTION MATRIX — R MODE   MIDDLE FREDA SANDSTONE

NAME	INDEX	STQTZ 6	META 4	KSPAR 8	UNQTZ 5	SEDS 3	OTHER 12	OPAQUE 10	PLAGIO 9
STQTZ	6	1.000	.000	.000	.000	.000	.000	.000	.000
META	4	.000	1.000	.000	.000	.000	.000	.000	.000
POLY	7	-.319	.448	-.372	-.407	-.271	-.148	-.441	.171
KSPAR	8	.000	.000	1.000	.000	.000	.000	.000	.000
EPID	11	.102	-.582	-.958	-.803	-.183	.439	-.939	.104
UNQTZ	5	.000	.000	.000	1.000	.000	.000	.000	.000
MAFIC	1	-.661	-.084	-.544	-.777	-.172	-.124	-.248	-.225
SILIC	2	-.688	-.252	-.488	-.790	-.061	-.171	-.476	-.415
SEDS	3	.000	.000	.000	.000	1.000	.000	.000	.000
OTHER	12	.000	.000	.000	.000	.000	1.000	.000	.000
OPAQUE	10	.000	.000	.000	.000	.000	.000	1.000	.000
PLAGIO	9	.000	.000	.000	.000	.000	.000	.000	1.000

OTT ORONTO HITE, PERCENT GRAINS, R MODE Q MORE UPPER FREDA

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	3.473	28.9	28.9	30.9	30.9
2	2.084	17.4	46.3	18.5	49.5
3	1.561	13.0	59.3	13.9	63.3
4	1.412	11.8	71.1	12.6	75.9
5	.911	7.6	78.7	8.1	84.0
6	.792	6.6	85.3	7.1	91.1
7	.583	4.9	90.1	5.2	96.2
8	.422	3.5	93.7	3.8	100.0
9	.342	2.9	96.5		
10	.272	2.3	98.8		
11	.140	1.2	99.9		
12	.007	.1	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 11.239

DOTT ORONTO HITE, PERCENT GRAINS, R MODE C MODE BAYFIELD

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	3.671	30.6	30.6	33.4	33.4
2	1.902	15.8	46.4	17.3	50.7
3	1.452	12.1	58.5	13.2	64.0
4	1.258	10.5	69.0	11.5	75.4
5	.828	6.9	75.9	7.5	83.0
6	.800	6.7	82.6	7.3	90.3
7	.569	4.7	87.3	5.2	95.4
8	.501	4.2	91.5	4.6	100.0
9	.446	3.7	95.2		
10	.345	2.9	98.1		
11	.228	1.9	100.0		
12	.000	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000
COMMUNALITY OVER 12 FACTORS = 12.000
8 FACTORS = 10.981

REORDERED OBLIQUE PROJECTION MATRIX — R MODE ORIENTA SANDSTONE OF THE BAYFIELD GROUP

NAME INDEX	OTHER 12	META 4	STQTZ 6	MAFIC 1	OPAQUE 10	POLY 7	EPID 11	SILIC 2
OTHER 12	1.000	.000	.000	.000	.000	.000	.000	.000
SEDS 3	.840	-.339	.518	-.606	.357	.254	.134	.781
PLAGIO 9	.658	-.069	-.036	.610	-.297	-.071	.316	-.064
META 4	.000	1.000	.000	.000	.000	.000	.000	.000
STQTZ 6	.000	.000	1.000	.000	.000	.000	.000	.000
KSPAR 8	-.574	.631	-.642	.550	.582	-.351	-.158	.154
MAFIC 1	.000	.000	.000	1.000	.000	.000	.000	.000
OPAQUE 10	.000	.000	.000	.000	1.000	.000	.000	.000
UNQTZ 5	.136	-.387	-.345	-.479	-.587	.065	.043	-.452
POLY 7	.000	.000	.000	.000	.000	1.000	.000	.000
EPID 11	.000	.000	.000	.000	.000	.000	1.000	.000
SILIC 2	.000	.000	.000	.000	.000	.000	.000	1.000

DOTT ORONTO HITE, PERCENT GRAINS, R MODE Q MODE JACOBSVILLE

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER ALL (12) FACTORS		8 ROTATED FACTORS	
1	4.865	40.5	40.5	41.4	41.4
2	2.459	20.5	61.0	20.9	62.4
3	1.483	12.4	73.4	12.6	75.0
4	1.172	9.8	83.2	10.0	85.0
5	.780	6.5	89.7	6.6	91.6
6	.470	3.9	93.6	4.0	95.6
7	.306	2.6	96.1	2.6	98.2
8	.208	1.7	97.9	1.8	100.0
9	.149	1.2	99.1		
10	.085	.7	99.8		
11	.023	.2	100.0		
12	.000	.0	100.0		

TRACE OF ORIGINAL MATRIX 12.000

COMMUNALITY OVER 12 FACTORS = 12.000

8 FACTORS = 11.743

REORDERED OBLIQUE PROJECTION MATRIX —— R MODE JACOBSVILLE FORMATION

NAME		MAFIC	META	SILIC	POLY	EPID	OTHER	OPAQUE	KSPAR
	INDEX	1	4	2	7	11	12	10	8
MAFIC	1	1.000	.000	.000	.000	.000	.000	.000	.000
PLAGIO	9	.582	.077	-.181	.391	-.050	-.240	.500	.212
STQTZ	6	-.656	.222	-.595	-.148	-.173	.141	.613	-.601
META	4	.000	1.000	.000	.000	.000	.000	.000	.000
SEDS	3	.541	.628	.071	.464	-.074	-.027	.255	.432
SILIC	2	.000	.000	1.000	.000	.000	.000	.000	.000
POLY	7	.000	.000	.000	1.000	.000	.000	.000	.000
EPID	11	.000	.000	.000	.000	1.000	.000	.000	.000
OTHER	12	.000	.000	.000	.000	.000	1.000	.000	.000
OPAQUE	10	.000	.000	.000	.000	.000	.000	1.000	.000
UNQTZ	5	.249	-.600	-.112	-.205	.155	-.155	-.815	-.181
KSPAR	8	.000	.000	.000	.000	.000	.000	.000	1.000

TITLE OF THESIS SEDIMENTOLOGY OF THE UPPER KEWEENAWAN SEQUENCE OF NORTHERN WISCONSIN AND ADJACENT MICHIGAN

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Publications

Major Department GEOLOGY

Minor(s) OCEANOGRAPHY

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