Sedimentology and Stratigraphy
Laboratory 3
Carbonate Sedimentary Rocks

Purpose: In this exercise, you will examine samples of various carbonate rocks in order to become familiar with carbonate rock classification and the concept of carbonate facies.

Method: The exercise consists of two parts. For Part I, you will examine and classify hand samples of various limestone types. In Part II, you will utilize thin sections of limestone to classify the associated rocks by name and facies.

Part I

In this part of the exercise you will examine hand specimens of some common kinds of carbonate rock, and classify each one according to textural, compositional, and structural features. For each sample you will:

A. determine nature of the binding material
B. determine abundance and distribution of allochems
C. determine sizes of allochems
D. determine types of allochems
E. determine structure of rock
F. assign an appropriate facies.

Procedure:

1) Enter all data on Table I.
2) Using the binocular microscope, and especially looking at any available thin edges of rock, determine whether the rock is bound primarily by sparry cement or by matrix. The cement will usually appear to be glassy, allowing allochems below the rock surface to be seen through the cement. Matrix will be extremely fine grained and opaque.
3) Determine whether allochems make up 10% or more of the rock. Note whether the allochems are dominantly 'floating' or touching each other.
4) Using your grain comparator, determine the average size of allochems.
5) Determine whether the allochems are ooliths (rounded clasts of micrite with concentric rings), peloids (ovoid, very fine grained, no trace of concentric lamina), lithoclasts (large micrite clasts), or skeletal (fossil fragments).
6) Does the rock have any obvious overall structural features, such as cross bedding, lamination, in situ skeletal framework, etc.?
7) Using the attached Embry & Klovan (1971) classificatory scheme (modified after Dunham (1962)), classify each of the hand samples.
8) Add modifying adjectives as necessary. Examples might be: skeletal wackestone of coralline framestone.
9) Specify the energy level of the system.
10) Which of the carbonate facies described by Wilson (1975) (attached) best describes this sample?
11) Repeat the above procedure with each of the six samples provided.

Part II

In this part of the exercise, you will examine carbonate rocks in thin section, and classify each rock according to allochem composition. For each sample you will:

A) determine the overall abundance of allochems
A) determine the relative proportions of each major allochem type
B) determine the nature of the binding material
C) determine the degree of neomorphism
D) classify the rock
F) assign the rock to an appropriate carbonate facies.

<u>Procedure:</u>

1) Enter all data in Table II.
2) Using the petrographic microscope, estimate the relative percentages of each of the major allochem types. Appropriate categories for allochem type include: brachiopods, bivalves, gastropods, bryozoans, corals, forams, algae, trilobites, peloids, intraclasts, ooids, oncoids, etc. Estimations can be made by using the attached visual estimation charts.
3) Estimate the percentage of the sample which is, or was, micrite.
4) Estimate the relative proportion of matrix vs cement as pore filling.
5) If cement is present, note the dominate forms of cement and their relative proportions.
6) Specify the degree to which neomorphism has affected this sample, and indicate which components of the sample have been most affected.
7) Classify this sample according to the Folk (1962) classificatory scheme (attached).
8) Which of the carbonate facies described by Wilson (1975) (attached) best describes this sample?
9) Repeat the above procedure with each of the four samples provided.

<u>Tips for Recognition of Neomorphic Spar</u>

1) Crystals tend to be cloudy with many inclusions.
2) No regular increase in crystal size away from grains.
3) 'Ghosts' of original structures preserved in grains, particularly fossils.
4) Undulose extinction.
5) Often uniform crystal size,especially in microspar.
6) Gradational contacts with unaltered spar.
7) 'Floating' grains in spar.
8) Crystals including both original grain and matrix area.

COMPARISON CHARTS FOR VISUAL ESTIMATION OF PERCENTAGE COMPOSITION

AGI 6

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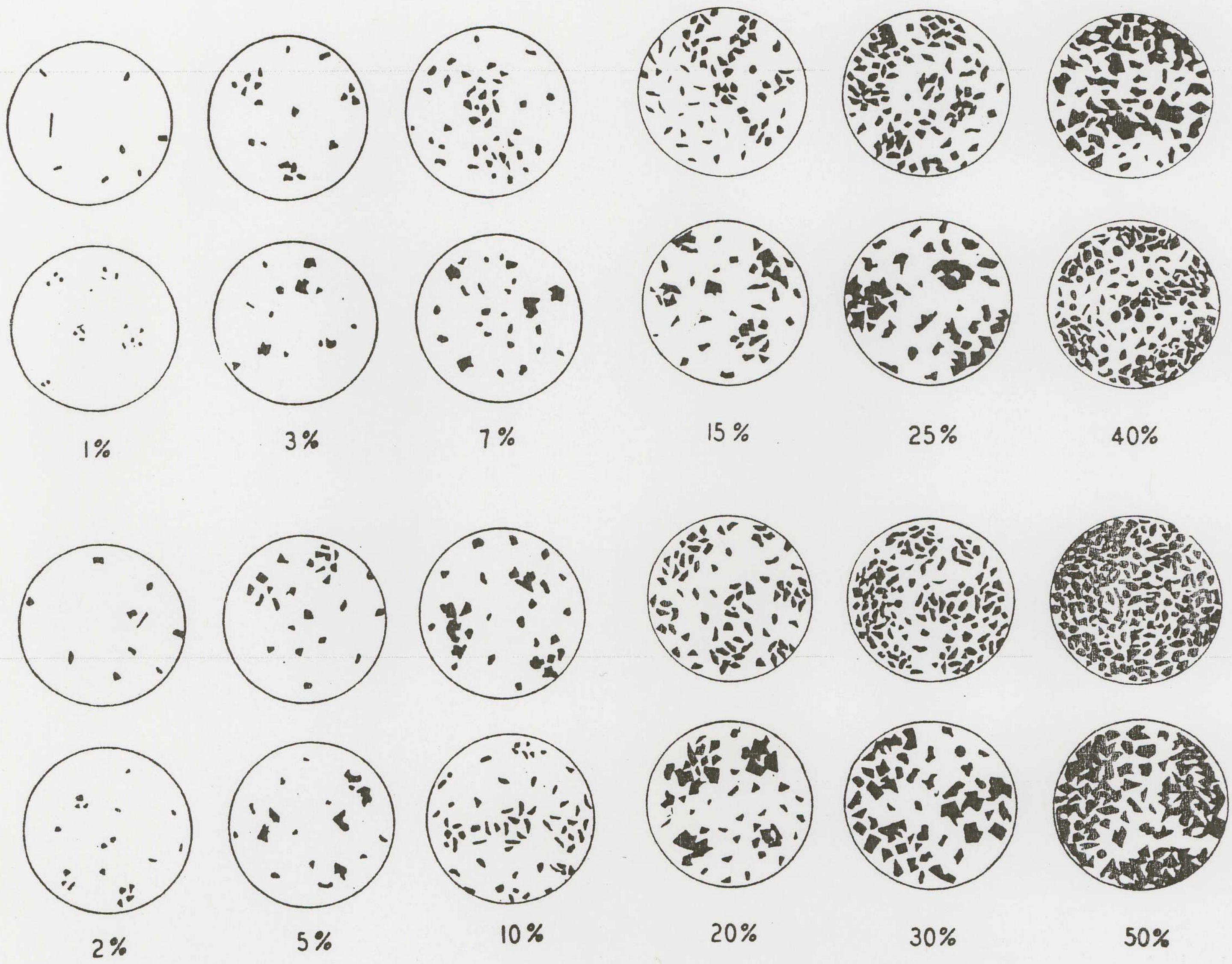


Additional copies of this data sheet may be obtained from the AMERICAN GEOLOGICAL INSTITUTE, 2101 Constitution Ave., N.W., Washington 25, D. C. $0.10.

<table>
<tr><td colspan="6">ALLOCHTHONOUS LIMESTONES
ORIGINAL COMPONENTS NOT ORGANICALLY BOUND DURING DEPOSITION</td><td colspan="3">AUTOCHTHONOUS LIMESTONES
ORIGINAL COMPONENTS ORGANICALLY BOUND DURING DEPOSITION</td></tr>
<tr><td colspan="4">LESS THAN 10% > 2mm COMPONENTS</td><td colspan="2">GREATER THAN 10% > 2mm COMPONENTS</td><td rowspan="4">BY ORGANISMS WHICH ACT AS BAFFLES</td><td rowspan="4">BY ORGANISMS WHICH ENCRUST AND BIND</td><td rowspan="4">BY ORGANISMS WHICH BUILD A RIGID FRAMEWORK</td></tr>
<tr><td colspan="3">CONTAINS LIME MUD (<.03 mm)</td><td>NO LIME MUD</td><td rowspan="3">MATRIX SUPPORTED</td><td rowspan="3">> 2mm COMPONENT SUPPORTED</td></tr>
<tr><td colspan="2">MUD SUPPORTED</td><td colspan="2" rowspan="2">GRAIN SUPPORTED</td></tr>
<tr><td>LESS THAN 10% GRAINS (>.03mm <2mm)</td><td>GREATER THAN 10% GRAINS</td></tr>
<tr><td>MUD-STONE</td><td>WACKE-STONE</td><td>PACK-STONE</td><td>GRAIN-STONE</td><td>FLOAT-STONE</td><td>RUD-STONE</td><td>BAFFLE-STONE</td><td>BIND-STONE</td><td>FRAME-STONE</td></tr>
</table>

Fig. 2. Classification of limestones according to depositional texture.

TABLE 8.2 Classification of carbonate rocks

Volumetric allochem composition			Limestones, partly dolomitized limestones, and primary dolomites (see Notes 1 to 6): >10% Allochems, Allochemical rocks (I and II): Sparry calcite cement > microcrystalline ooze matrix — Sparry allochemical rocks (I)	Limestones, partly dolomitized limestones, and primary dolomites (see Notes 1 to 6): >10% Allochems, Allochemical rocks (I and II): Microcrystalline ooze matrix > sparry calcite cement — Microcrystalline allochemical rocks (II)	<10% Allochems, Microcrystalline rocks (III): 1–10% Allochems — Most abundant allochem	<10% Allochems, Microcrystalline rocks (III): <1% Allochems	Undisturbed bioherm rocks (IV)	Replacement dolomites[7] (V): Allochem ghosts — Evident allochem	Replacement dolomites[7] (V): No allochem ghosts
>25% Intraclasts (i)			Intrasparrudite (Ii:Lr) Intrasparite (Ii:La)	Intramicrudite* (IIi:Lr) Intramicrite* (IIi:La)	Intraclasts: intraclast-bearing micrite* (IIIi:Lr or La)	Micrite (IIIm:L); if disturbed, dismicrite (IIImX:L); if primary dolomite, dolomicrite (IIIm:D)	Biolithite (IV:L)	Finely crystalline intraclastic dolomite (Vi:D3) etc.	Medium crystalline dolomite (V:D4)
<25% Intraclasts	>25% Oölites (O)		Oösparrudite (Io:Lr) Oösparite (Io:La)	Oömicrudite* (IIo:Lr) Oömicrite* (IIo:La)	Oölites: oölite-bearing micrite* (IIIo:Lr or La)			Coarsely crystalline oölitic dolomite (Vo:D5) etc.	Finely crystalline dolomite (V:D3)
<25% Intraclasts	<25% Oölites	Volume ratio of fossils to pellets: >3:1 (b)	Biosparrudite (Ib:Lr) Biosparite (Ib:La)	Biomicrudite (IIb:Lr) Biomicrite (IIb:La)	Fossils: fossiliferous micrite (IIIb: Lr, La, or L1)			Aphanocrystalline biogenic dolomite (Vb:D1) etc.	
<25% Intraclasts	<25% Oölites	Volume ratio of fossils to pellets: 3:1–1:3 (bp)	Biopelsparite (Ibp:La)	Biopelmicrite (IIbp:La)	Pellets: pelletiferous micrite (IIIp:La)			Very finely crystalline pellet dolomite (Vp:D2) etc	etc.
<25% Intraclasts	<25% Oölites	Volume ratio of fossils to pellets: <1:3 (p)	Pelsparite (Ip:La)	Pelmicrite (IIp:La)					

*Designates rare rock types.

[1]Names and symbols in the body of the table refer to limestones. If the rock contains more than 10 percent replacement dolomite, prefix the term "dolomitized" to the rock name, and use DLr or DLa for the symbol (e.g., dolomitized intrasparite, Li:DLa). If the rock contains more than 10 percent dolomite of uncertain origin, prefix the term "dolomitic" to the rock name, and use dLr or dLa for the symbol (e.g., dolomitic pelsparite, Ip:dLa). If the rock consists of primary (directly deposited) dolomite, prefix the term "primary dolomite" to the rock name, and use Dr or Da for the symbol (e.g., primary dolomite intramicrite, IIi:Da). Instead of "primary dolomite micrite" (IIIm:D) the term "dolomicrite" may be used.

[2]Upper name in each box refers to calcirudites (median allochem size larger than 1.0 mm); lower name refers to all rocks with median allochem size smaller than 1.0 mm. Grain size and quantity of ooze matrix, cements, or terrigenous grains are ignored.

[3]If the rock contains more than 10 percent terrigenous material, prefix "sandy," "silty," or "clayey" to the rock name and "Ts," "Tz," or "Tc" to the symbol, depending on which is dominant (e.g., sandy biosparite, TsIb:La, or silty dolomitized pelmicrite, TzIIp:DLa). Glauconite, collophane, chert, pyrite, or other modifiers may also be prefixed.

[4]If the rock contains other allochems in significant quantities that are not mentioned in the main rock name, these should be prefixed as qualifiers proceeding the main rock name (e.g., fossiliferous intrasparite, oölitic pelmicrite, pelletiferous oösparite, or intraclastic biomicrudite). This can be shown symbolically as Ii(b), Io(p), IIb(i), respectively.

[5]If the fossils are of rather uniform type or one type is dominant, this fact should be shown in the rock name (e.g., pelecypod biosparrudite, crinoid biomicrite).

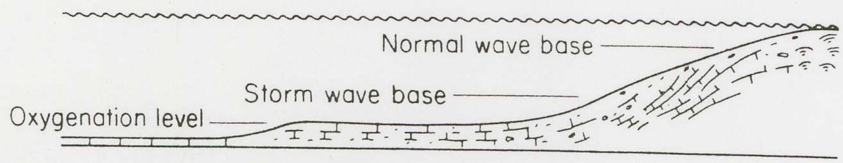
[6]If the rock was originally microcrystalline and can be shown to have recrystallized to microspar (5–15 microns, clear calcite) the terms "microsparite," "biomicrosparite," etc., can be used instead of "micrite" or "biomicrite."

[7]Specify crystal size as shown in the examples.

Source: Folk, R. [illegible] 1962, Spectral subdivision of limestone types, *in* W. E. Ham (ed.), Cla[illegible]cation of carbonate rocks: Am. Assoc. Petroleum Geologists Mem. 1. Table [illegible] p. 70, reprinted by per[illegible]ion of AAPG, Tulsa, Okla.

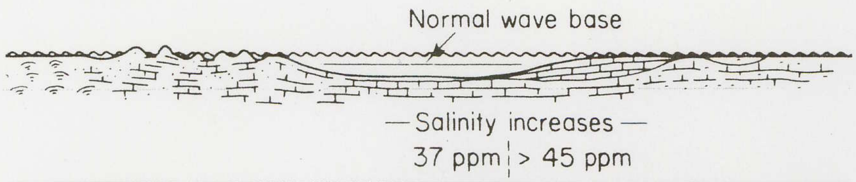
TABLE 19-3 IDEALIZED SEQUENCE OF STANDARD FACIES BELTS.*

Diagrammatic



	Basin-starved or filled: Little benthonic carbonate produced. Sedimentation depends on influx of detrital silicates and plankton.	*Open shelf:* Water depth 10 to 100s m. Normal marine salinity. Minor sediment transport by currents.	*Basin margin:* Toe of the slope. Sediment derived from plankton.	*Foreslope:* Slope may be 30°. Sediment moved by gravity, waves, currents.
Facies	(a) Fine clastics (b) Carbonates (c) Evaporites	Open marine neritic (a) Carbónates (b) Shale		(a) Bedded fine grained sediments with slumps (b) Foreset debris and lime sands (c) Lime mud masses
Lithology	Dark shale or silt, thin limestones (starved basin); evaporite fill with salt	Very fossiliferous limestone interbedded with marls; well-segregated beds	Fine-grained limestone; cherty in some cases	Variable, depending on water energy upslope; sedimentary breccias and lime sands
Color	Dark brown, black, red	Gray, green, red, brown	Dark to light	Dark to light
Grain type and depositional texture	Lime mudstones; fine calcisiltites	Bioclastic and whole fossil wackestones; some calcisiltites	Mostly lime mudstone with some calcisiltites	Lime silt and bioclastic wackestone-packstone; lithoclasts of varying sizes
Bedding and sedimentary structures	Very even mm lamination; rhythmic bedding; ripple cross lamination	Thoroughly burrowed; thin to medium, wavy to nodular beds; bedding surfaces show diastems	Lamination may be minor; many massive beds; lenses of graded sediment; lithoclasts and exotic blocks, rhythmic beds	Slump in soft sediments; foreset bedding; slope bioherms; exotic blocks
Terrigenous clastics admixed or interbedded	Quartz silt and shale; fine-grained siltstone; cherty	Quartz silt, siltstone, and shale; well-segregated beds	Some shales, silt, and fine-grained siltstone	Some shales, silt, and fine-grained siltstone
Biota	Exclusively nektonic-pelagic fauna preserved in local abundance on bedding planes	Very diverse shelly fauna preserving both infauna and epifauna	Bioclastic detritus derived principally from upslope	Colonies of whole fossil organisms and bioclastic debris

cross section



Organic-build up	*Platform edge sands:* Water depth 10 – 0 m Tidal bars, tidal deltas. Few organisms due to shifting substrate.	*Open platform:* Shallow marine < 10 m Normal marine limited fauna	*Restricted shelf tidal flats:* Fine sediment in ponds, coarse in tidal channels and beaches wind deposited detrital silicates and swamps	*Evaporative:* Supratidal sabkha-salinas, saltflats. Arid climate, land derived detrital silicates
(a) Boundstone mass (b) Crust on accumulation of organic debris and lime mud; bindstone (c) Bafflestone	(a) Shoal lime sands (b) Islands with dune sands	(a) Lime sand bodies (b) Wackestone-mudstone areas, bioherms (c) Areas of clastics	(a) Bioclastic wackestone in lagoons and bays (b) Litho-bioclastic sands in tidal channels (c) Lime mud-tide flats (d) Fine clastic units	(a) Nodular anhydrite and dolomite on salt flats (b) Laminated evaporite in ponds
Massive limestone-dolomite	Calcarenitic-oolitic lime sand or dolomite	Variable carbonates and clastics	Generally dolomite and dolomitic limestone	Irregularly laminated dolomite and anhydrite, may grade to red beds
Light	Light	Dark to light	Light	Red, yellow, brown
Boundstones and pockets of grainstone; packstone	Grainstones well sorted, rounded	Great variety of textures; grainstone to mudstone	Clotted, pelleted mudstone and grainstone; laminated mudstone; coarse lithoclastic wackestone in channels	
Massive organic structure or open framework with roofed cavities; Lamination contrary to gravity	Medium-to-large scale cross-bedding; festoons common	Burrowing traces very prominent	Birdseye, stromatolites, mm lamination, graded bedding, dolomite crusts on flats. Cross-bedded sand in channels	Anhydrite after gypsum, nodular, rosettes, chickenwire and blades; irregular lamination; carbonate caliche
None	Only some quartz sand admixed	Carbonates and detrital silicates in well segregated beds	Detrital silicates and carbonates in well segregated beds	Windblown, land derived admixtures; clastics may be important units
Major frame building colonies with ramose forms in pockets; in situ communites dwelling in certain niches	Worn and abraded coquinas of forms living at or on slope; few indigenous organisms	Open marine fauna lacking (e.g., echinoderms, cephalopods, brachiopods); mollusca, sponges, forams, algae abundant; patch reefs present	Very limited fauna, mainly gastropods, algae, certain foraminifera (e.g., miliolids) and ostracods	Almost no indigenous fauna, except for stromatolitic algae

Table I

Sample # ____________________

Type of binder (cement, matrix): ____________________

Grains make up <10%, >10% of the rock: ____________________

Grains are: touching, floating? ____________________

Average grain size: ____________________

Grain type(s): ____________________

Rock structure: ____________________

Rock name: ____________________

Energy level of depositional environment (low, intermediate, high):

____

Most appropriate facies: ____________________

Sample # ____________________

Type of binder (cement, matrix): ____________________

Grains make up <10%, >10% of the rock: ____________________

Grains are: touching, floating? ____________________

Average grain size: ____________________

Grain type(s): ____________________

Rock structure: ____________________

Rock name: ____________________

Energy level of depositional environment (low, intermediate, high):

____

Most appropriate facies: ____________________

Sample # ____________________

Type of binder (cement, matrix): ____________________

Grains make up <10%, >10% of the rock: ____________________

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Average grain size: ____________________

Grain type(s): ____________________

Rock structure: ____________________

Rock name: ____________________

Energy level of depositional environment (low, intermediate, high):

____

Most appropriate facies: ____________________

Table I (con'd)

Sample # ____________________
Type of binder (cement, matrix): ____________________
Grains make up <10%, >10% of the rock: ____________________
Grains are: touching, floating? ____________________
Average grain size: ____________________
Grain type(s): ____________________
Rock structure: ____________________
Rock name: ____________________
Energy level of depositional environment (low, intermediate, high):
____
Most appropriate facies: ____________________

Sample # ____________________
Type of binder (cement, matrix): ____________________
Grains make up <10%, >10% of the rock: ____________________
Grains are: touching, floating? ____________________
Average grain size: ____________________
Grain type(s): ____________________
Rock structure: ____________________
Rock name: ____________________
Energy level of depositional environment (low, intermediate, high):
____
Most appropriate facies: ____________________

Sample # ____________________
Type of binder (cement, matrix): ____________________
Grains make up <10%, >10% of the rock: ____________________
Grains are: touching, floating? ____________________
Average grain size: ____________________
Grain type(s): ____________________
Rock structure: ____________________
Rock name: ____________________
Energy level of depositional environment (low, intermediate, high):
____
Most appropriate facies: ____________________

Table II

Sample # ____________________

Allochems

Category | Relative % of total allochems

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% Micrite ______________

% of pore filling cement ____________

% of pore filling matrix ______________

Dominate cement types and their relative proportions ____________________

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Degree of neomorphism and the components most affected ________________

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____

Classification ____________________________________

Carbonate facies ____

Sample # ____________________

Allochems

Category | Relative % of total allochems

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% Micrite ______________

% of pore filling cement ____________

% of pore filling matrix ______________

Dominate cement types and their relative proportions ____________________

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Degree of neomorphism and the components most affected ________________

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Classification ____________________________________

Carbonate facies ____

Table II (con'd)

Sample # ______________________

Allochems

<u>Category</u> <u>Relative % of total allochems</u>

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% Micrite ________________
% of pore filling cement ______________
% of pore filling matrix ________________
Dominate cement types and their relative proportions ______________________
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Degree of neomorphism and the components most affected __________________
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Classification ______________________________________
Carbonate facies ____

Sample # ______________________

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<u>Category</u> <u>Relative % of total allochems</u>

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Classification ______________________________________
Carbonate facies ____

Table II (con'd)

Sample # ____________________

Allochems

Category — Relative % of total allochems

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Dominate cement types and their relative proportions ____________
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Degree of neomorphism and the components most affected ____________
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Classification ____________________
Carbonate facies ____________________

Sample # ____________________

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Classification ____________________
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