EXERCISE 9
FACIES ANALYSIS

Introduction

As you are aware, in physics and chemistry, known procedures are followed in carefully controlled experiments to see what unknown products will result. After the products have formed, they are directly observed and related exactly to the formative processes. The reasoning is from process to product. By contrast, in geology the rocks are known products and the formative processes are the unknowns. Geology is thus unique among the sciences in that the geologist starts with the result (the rocks) and asks, in effect, "What was the experiment?"

Exercises 1 through 8 dealt with the compositional and textural nature of sedimentary particles and the myriad combinations in which such particles may accumulate in nature. These particle assemblages (rocks and sedimentary deposits) are the products of sedimentary processes operative in natural settings called depositional environments. This exercise provides an introduction to facies analysis, the interpretation of the rock record for purposes of reconstruction of the physical, chemical and biological processes that were responsible for the original sediments.

Depositional Environments and Facies

The geologist must be familiar with modern sediments and laboratory experiments with sediments where close relationships between processes and products have been established. It is important to recognize, however, that in dealing with natural processes, geologists are confronted not with the products of processes that operated in isolation but rather with products of associated processes that operated collectively in depositional environments. Deposits which evolve in specific depositional environments, such as intertidal flats, in desert lakes, or in salt marshes, are considered to be sedimentary facies. The term facies refers to the lithologic and biologic characteristics of a sedimentary deposit imparted by the processes operating in the depositional environments. Some examples of facies in the rock record are fluvial facies, eolian facies, and tidal facies, to mention just a few. Because many depositional environments exist simultaneously, and because the geographic extent of any given environment is not infinite, the sediments deposited simultaneously change facies from place to place; that is, various facies interfinger with one another. Accordingly, a beach facies may interfinger landwards with a coastal-dune facies, and this, in turn, may pass into fluvial and other nonmarine facies. In the seaward direction, a beach facies may interfinger with various shallow marine facies, which ultimately may interfinger with deep-sea facies. The modern usage of facies with its specific emphasis on facies changes stresses this interfingering.

A given facies is deposited only within the area occupied by its specific depositional environment. In other words, at any one time, geography determines the horizontal dimensions of each facies. This being true, how is it possible for a facies to eventually occupy a wider area than that occupied by its depositional environment? The answer to this is that the boundaries of the environments shift with time. As these boundaries migrate, the characteristic deposits of the environment are even more widely distributed. In this way, many facies are spread laterally with time and are "stacked" vertically on top of one another.

There are three general groups of depositional environments: (1) nonmarine, (2) marine, and (3) transitional between nonmarine and marine. Table 9-1 is a tabulation of those depositional environments which are important for purposes of this exercise in facies analysis.

Group	Environment	Sub-Environment
Nonmarine	Alluvial	Channel Overbank Marsh and Swamp
Transitional	Tidal	Channel Flat
Marine	Nearshore Offshore	

Sedimentary Environments Considered in Exercise 9

Table 9-1

There are, of course, many other environments which in some geographic areas and some parts of the rock record are very important, but which do not happen to be represented in this exercise. Detailed information on the characteristics of all the recognized depositional environments and facies may be found in the following references:

Braunstein, Jules, 1974, Facies and the reconstruction of environments: Tulsa, American Assoc. Petroleum Geologists Reprint Series No. 10, 223 p.

Curtis, D. M., Compiler, 1978, Depositional environments and paleoecology: Environmental models in ancient sediments: Tulsa, Society of Economic Paleontologists and Mineralogists Reprint Series No. 6, 240 p.

Dunbar, C. O.; and Rodgers, John, 1957, Principles of stratigraphy: New York, John Wiley & Sons, 356 p.

Friedman, Gerald M.; and Sanders, John E., 1978, Principles of sedimentology: New York, John Wiley & Sons, 553 p. Part V (Modern sedimentary environments and their products in the rock record, p. 195-401).

Matthews, R. K., 1974, Dynamic stratigraphy: Englewood Cliffs, New Jersey, Prentice-Hall, 370 p. Part III (Sedimentary environments from the mountains to the deep sea, p. 135-318).

Reading, H. G., ed., 1978, Sedimentary environments and facies: New York, Elsevier, 557 p.

Selley, R. C., 1970, Ancient sedimentary environments: London, Chapman and Hall, Ltd., 237 p.

A depositional environment is considered as being defined by a set of values of physical, chemical, and biological variables that correspond to a particular geomorphic unit, such as an alluvial flood plain, a lagoon, or a tidal flat. The interplay of processes operating within a given environment gives the sedimentary deposit distinctive physical, chemical, and biological characteristics. The characteristics are variable in the extent to which they are preserved in the rock record. Physical characteristics (such as sedimentary structures) are commonly well preserved, but chemical characteristics may be altered by diagenetic processes, and biologic elements may in large part be lost by selective destruction due to oxidation, reduction, or chemical solution.

In order to recognize sedimentary facies in the geologic record it is necessary to use multiple recognition criteria including: (1) sedimentary structures, (2) lithology, (3) geometric relationships of rock units, and (4) character of biologic content.

The following tables include information on the specific characteristics of the rock facies which evolved in the depositional environments outlined in Table 9-1. These characteristics are typical for sedimentary rocks deposited as a clastic wedge at the margin of a basin where the source area was a nearby orogenic zone dominated by low-grade metamorphic rocks.

	Channel	Overbank
Lithology	Gray and greenish gray, fine to medium-grained, immature argillaceous rock fragment-quartz sandstone containing abundant carbonaceous debris and green shale pebbles (shale pebble conglomerate), especially in lower 0.5 to 1 m of sandstone body.	Red and green, locally mottled siltstones, mudstones and shales with sporadic dark gray, locally bituminous lenses and very sparse thin, greenish tan, highly calcareous siltstone beds.
Texture	Variable; poorly sorted with abundant "fines," commonly becoming finer-grained upward in sandstone body.	Consistently of silt and clay grain-size with very small admixtures of very fine sand grains.
Sedimentary Structures	Tabular and trough cross-bedding ubiquitous, commonly with decreasing foreset thickness and inclination upward in sandstone body. Parting lineation common. Current ripple marks locally well developed.	Very thin parallel laminae which generally are obscure on even slightly weathered outcrops; locally bedding is shaly. Local occurrence of mud-cracks.
Geometry	Basal contact truncates strata of underlying unit; upper contact gradational into siltstone of overbank facies. In cross-section sandstone body may interfinger with overbank facies or may be lenticular. Many bodies are laterally extensive. Where abundant subsurface control is available, bodies would be elongate and exhibit bifurcating patterns.	Facies occurs interbedded with channel sandstones. Basal contact with sandstone body gradational; upper contact a sharp, channelled disconformity. Interfingers laterally with channel facies.
Associations	Sandstone bodies of facies occur as cyclic, "multistory" interbeds in red and green and locally dark gray and black, highly organic siltstones and shales of overbank and marsh facies.	See Geometry. Green coloration occurs in red siltstones and mudstones as mottles, lenses and very thin, persistent layers.
Miscellaneous	Outcrop surfaces commonly iron-stained. Iron sulfates (melanterite and jarosite) commonly occur on organic, pyrite-rich lenses. Only contained fossils are plant material, sparse freshwater bivalves and fish plates.	Only fossils are plant material. Locally burrows, green burrow mottling and yellow-green, very slightly calcareous plant stigmaria are abundant.

Summary of diagnostic characteristics of the alluvial facies.

Table 9-2

	Flat	Channel
Lithology	Medium dark gray, finely micaceous, muddy siltstone and very subordinate medium gray, very fine-grained sandstone.	Medium gray, fine-grained, immature rock fragment-quartz sandstone containing abundant plant materials; coquinoid sandstone and coquinite with spiriferid brachiopods; polymictic conglomerate with pebbles of gray, light green, and olive siltstone, greenish gray quartzite and red siltstone and shale.
Texture	Very fine to fine gradesizes.	Grain-size decreases upward in rock unit from conglomerate lenses in base to very fine-grained sandstone at top. Sorting is generally poor.
Sedimentary Structures	Featureless to very fine cross-laminated (flaser and ripple bedding). Local, well developed polygonal mud-cracks and oscillation ripple marks.	Tabular and trough cross-bedding ubiquitous in basal part of sandstone, grading upward into generally horizontal bedding at top. Parting lineation common in upper part of body.
Geometry	Basal contact gradational from sandstones of inferred tidal or nearshore bar origin. Upper contact disconformable with overlying tidal channel sandstone or nearshore bar sandstone.	Basal contact truncates strata of underlying inferred tidal flat facies. Upper contact gradational into fine-grained rocks of tidal flat or other facies. In cross-section may be lenticular or interfinger with tidal flat facies. In modern environments long axis of sand body generally perpendicular to shoreline.
Associations	Interbedded with sandstones of inferred nearshore bar and tidal channel origin.	Sandstone bodies occur as channel deposits in tidal flat facies. Basal lag concentrate is commonly coquinite or coquinoid sandstone.
Miscellaneous	Contains abundant plant material and common allochthonous brachiopods.	Internal sedimentary structural configuration the same as that of alluvial channel facies. Sandstones contain local large burrow structures and allochthonous marine fossils

Summary of diagnostic characteristics of the tidal facies.

Table 9-3

Lithology	Predominantly medium gray and olive gray sandstone. Although of low maturity index, relatively "clean" compared to tidal and alluvial sandstones. Variability low. Subordinate medium gray siltstone containing abundant wood material.
Texture	Very fine-grained sand. Maturity index, although low, is higher than in tidal and alluvial sandstones. Variability of texture low.
Sedimentary Structures	Very shallow cross-bedding in sandstones. Oscillation and current ripple marks locally abundant. Flow rolls locally well-developed, especially at distal margin of nearshore facies. Wave and current directional indicators suggest variable direction of sediment transport.
Geometry	Bar sandstones lenticular in cross-section. Basal contacts on offshore siltstones are of both transitional and abrupt types.
Associations	Nearshore sandstones interbedded with siltstones and shales of lagoon facies. General gradational fining-upward beneath transgressive shale tongue and coarsening-upward above tongue. Sandstones of nearshore facies grade shoreward into sandstones of tidal facies and basinward into siltstones of offshore facies.
Miscellaneous	Abundant brachiopods and pelecypods, many composed of original calcite. Some brachiopods occur in coquinoid, conglomeratic lenses. Vertical burrow structures locally abundant. Finely mascerated plant material ubiquitous.

Summary of diagnostic characteristics of the nearshore facies.

Table 9-4

Lithology	Medium gray, slightly calcareous to calcareous siltstone grading basinward into argillaceous micrite and biomicrite. Distal offshore strata are brownish black and very dark gray due to high content of very fine carbonaceous and bituminous fragments and disseminated iron sulfides.
Texture	Very fine (silt) grade sizes. Variability of texture low.
Sedimentary Structures	Bedding poor and very thin to laminated. Micro-cross-lamination ubiquitous. Wave and current directional indicators suggest greater constancy of sediment transport direction than in near-shore facies. Distal offshore rocks are massive and horizontally bedded with very fine parallel laminae. Weathered outcrops are very fissile.
Geometry	Distal offshore facies is a tongue penetrating shoreward into more proximal offshore rocks.
Associations	In landward direction, offshore siltstones interfinger with and grade into nearshore bar sandstones; in basinward direction grade into argillaceous micrite. Distal offshore strata grade downward into micrite and upward into more proximal offshore siltstones.
Miscellaneous	Abundant pelecypods and brachiopods, some composed of original calcite. Very fine plant material ubiquitous. Proximal offshore clastics contain horizontal burrow structures. Micrites contain well-developed "mottled" burrow structures. Distal offshore shale contains sparse fossils.

Summary of diagnostic characteristics of the offshore facies.

Table 9-5

Materials

The following materials will be needed for this exercise:

Metric scale
One sheet of 30 x 60 cm white drawing paper
Drawing pencils (2H, 4H)
Colored pencils

Procedures

The objective of this exercise is to introduce you to facies analysis. You are provided with field data in the form of a tabular description of the rock strata present in seven stratigraphic sections (Tables 9-6 through 9-12). You will plot this information on a stratigraphic cross-section and then, referring to Tables 9-2 through 9-5 as a guide, determine the spatial relationships of the sedimentary facies. As indicated earlier, these are rocks that evolved as a clastic wedge at the margin of a basin where the source area was a nearby orogenic zone dominated by low-grade metamorphic rocks. Clastic influx into the basin was high, so that the sorting of the rocks is generally quite poor.

The abbreviations used for the stratigraphic section descriptions in Tables 9-6 through 9-12 are:

gy. - gray, gn. - green, rd. - red, lt. - light,
gn.-gy. - greenish gray
f. - fine, m. - medium, c. - coarse, g. - grained
vy. - very, bdd. - bedded, lam. - laminated, calc. - calcareous,
slty. - silty, shly. - shaly, sndy. - sandy
Contacts: ———————— sharp, —— —— —— gradational
SS - sandstone, SH - shale, SLTST - siltstone,
MDST - mudstone

Top of Section

1 m	gy., v.f.g. SS
25 m	gy. SH, in upper part sandy and calc., grading downward into slty. SH
11 m	gy., shly. BIOMICRITE, burrowed, in part w horn corals and w occ. oscillation ripple marks
0.3 m	gy., INTRASPARITE w common SH chips, abundant oöids and sparse crinoid fragments
0.6 m	gy., calc., shly. SLTST, w interlam. of v.f.g. BIOSPARITE

Base of Section

NOTE: Use a point 8 m above the base of this section as datum for your stratigraphic cross-section.

Section 1

Table 9-6

Top of Section

12 m	gy. SH w burrow tubes and v.f. plant frags. grading downward through gy., vy. shallowly cross-lam. SLTST to gy., vy. shallowly cross-lam., slightly calc., v.f.g. SS
11 m	gy., cross-lam. and shly. SLTST w ubiquitous v.f. plant frags. and w vy. f. burrows and pelecypod casts.
13 m	gy., vy. shallowly cross-lam. SLTST and v.f.g. SS, in part burrowed, in part calc., w occ. oscillation ripple marks and brush casts
15 m	gy. vy. shallowly cross-lam. SLTST and v.f.g. SS as above, with occasional pyrite nodules
9 m	gy., vy. shallowly cross-lam. SLTST grading downward into calc. SLTST
17 m	gy., calc. SH and shly. SLTST with common burrow tubes, small horn corals and sparse vy. fine plant fragments
2 m	lt. gy., vy. fossiliferous, in part oölitic, in part highly burrowed, CALCILUTITE
	(Datum for stratigraphic cross-section)
	gy., shallowly cross-lam., silty v.f.g. SS

Base of Section

Section 2

Table 9-7

Top of Section

26 m	gy., shallowly cross-lam. f.g. SS grading downward into cross-lam. sndy. SLTST and SLTST, all w sparse v.f. plant fragments, in part w sparse to abundant brachiopod casts, w occ. small calc. or pyrite nodules
11 m	gy., cross-lam., shly. SLTST, w occ. small lenses of calc., v.f.g. SS.
13 m	gy., vy. shallowly cross-lam., f.g. SS w abundant v.f. plant fragments and sparse to very abundant brachiopod casts.
2 m	gy., dense, v.f.g. SS w ball & pillow structure and abundant brachiopod casts.
34 m	gy., shallowly cross-lam., f.g. SS, w sparse to abundant f.g. plant mat'l. & abundant, sometimes large, brachiopod casts; f.g. SS grades downward through gy. v.f.g. SS to darker gy., shly. SLTST, all w abundant v.f.g. plant mat'l., in part w brach. casts and w abundant current & oscill. ripple marks.
15 m	gy., vy. thin bdd. to shaly, in part calc., SLTST w pelecypod casts, v.f. plant fragments and occ. interbeds of vy. thin, vy. calc., v.f.g. SS.
1 m	gy., thin bdd., v.f.g. SS
2 m	interbedded gy., in part calc., SH and vy. thin bdd. BIOCALCARENITE w horn corals, abundant crinoid fragments and vy.f. plant fragments
	Datum for stratigraphic cross-section
44 m	gy. SH and vy. thin bdd. SLTST, in part sandy, w vy. thin interbeds of gy., calc., f.g. SS, all w common brachiopod casts and in part w v.f. plant frags., burrows, gastropod casts and crinoid fragments.

Base of Section

Section 3

Table 9-8

Top of Section

4 m	gn.-gy., med. cross-bdd. (foreset thickness >10 cm) m.-c.g. SS w abundant, in part coarse, plant fragments.
11 m	gy., shallow cross-lam. & thin to vy. thin bdd. SLTST w abundant f.-c. plant frags. & sparse to occ. abundant brachiopod casts.
9 m	gy., thin & vy. thin poorly bdd., v.f.g. SS w occ. SLT lenses, abundant f. plant frags., common to abundant brachiopod casts & occ. burrows.
28 m	olive gy. & lt. olive gy., thin poorly bdd. & finely cross-lam. SLTST w abundant fine plant frags. & common brachiopod casts.
9 m	gy., shallowly cross-bdd., calc., f.g. SS w abundant plant frags. & brachiopod and pelecypod casts, grading downward into gy., thinly bdd. & cross-lam. SLTST.
47 m	gy., thin & shallowly cross-bdd., f.g. SS w abundant f. plant frags. & occ. brachiopod casts.
15 m	gn.-gy., lam., cross-lam. & vy. thin bdd. SLTST w occ. brachiopod casts & abundant f. plant frags.
27 m	gy., thin, well-bdd., f.g. SS w abundant ball & pillow structures in lower 40' of interval, & w abundant f. plant frags., fucoids & brachiopod casts throughout entire interval.
7 m	gy., thin, vy. shallow cross-bdd. SLTST w abundant f. plant frags. & brachiopod casts & occ. fucoids.

Base of Section

NOTE: Use a point 61 m above the base of this section as datum for your stratigraphic cross-section.

Section 4

Table 9-9

Top of Section

1 m	gn.-gy., thin, vy. shallowly cross-bdd., highly calc., m.g. SS w abundant brachiopods composed of $CaCO_3$ & large burrows.
5 m	gn.-gy., thin, vy. shallowly cross-bedded, highly calc., m.g. SS w sltst & sh. pebbles, occ. pyrite nodules & c. plant frags.
6 m	Gy. SLTST w abundant f. plant frags.
8 m	gn.-gy., thin bdd. & cross-lam. to thick cross-bdd., f.g. SS w abundant f. plant frags.
1 m	gn.-gy., thin bdd. & cross-lam., shly., calc., f.g. SS, in part w sh. frags., in part vy. dense & "clean."
24 m	gn.-gy., variably bdd., v.f.g. SS, upper part "clean" & lower part w sh. peb. cglt. lenses, f. plant frags. and occ. abundant fucoids.
12 m	gy. SLTST w v.f.g. SS lenses, w abundant plant frags. & brachiopod casts.
6 m	gn.-gy., vy. thick bdd., f.g. SS w f. plant frags., grading downward into gy., thick bdd. v.f.g. SS w f. plant frags.
1.5 m	gy., thick bdd., f.g. SS interbdd. w gy., fissile SH.
4 m	gn.-gy., med. to thick bdd., f.g. SS w f. to c. plant frags., sparse brachiopod casts & sh. peb. cglt. lenses.

Base of Section

NOTE: Use a point 20 m below the top of this section as datum for your stratigraphic cross-section.

Section 5

Table 9-10

Top of Section

13 m	gy., vy. thin, vy. shallow cross-bdd. & cross-lam. f.g. SS w abundant f. plant frags., grading downward to slty. SS.
3 m	gy. SH & shly. SLTST w occ. pyrite nods.
0.3 m	gy., vy. calc., f.g. SS w abundant large, $CaCO_3$, brachiopods & f. plant frags.
0.3 m	dk. gy. SH w sparse pelecypod casts.
6 m	gn.-gy., thin shallow cross-bdd. & "flaggy," f.g. SS w abundant f. plant frags. & sparse burrows & occ. current ripple marks.
7 m	Interbedded gy., shly. SLTST & vy. calc., cgltc., f.g. SS w abundant $CaCO_3$ brachiopods. Pelecypod casts, f. plant frags. & oscillation & current ripple marks.
2 m	olive gy., vy. thin shallow cross-bdd. f.g. SS w common sh. pebs. & f. to c. plant frags.
3 m	gy., vy. thin, vy. shallow cross-bdd. & cross-lam. f.g. SS w f. plant frags. & occ. ball & pillow structures.
0.3 m	gy., vy. thin cross-bdd. & cross-lam., vy. calc., f.g. SS w abundant plant frags., brachiopod casts & pelecypod casts.
	Datum for stratigraphic cross-section
13 m	gy., vy. thin cross-bdd. & cross-lam., f.g. SS w abundant f. to c. plant frags. & burrows and occ. oscill. ripple marks.
0.6 m	olive gy., thin bdd., calc., f.g. SS w sh. partings and interference ripple marks.
3 m	greenish tan, mottled, slty. MUDSTONE.
11 m	gy., vy. thin, shallow cross-bdd., f.g. SS w abundant plant frags., grading downward into olive gray, f.g. SS.
5 m	gy., thin & vy. thin, shallow cross-bdd., sltly. calc. SLTST, in part w small pelecypods, vy. f. burrows & plant frags. and occ. calc. nodules.

Base of Section

Section 6

Table 9-11

Top of Section

11 m	gy.-gn., cross-bedded, f. - m.g. SS
14 m	rd. SLTST & MDST
5 m	gy.-gn., cross-bedded, fining-upwards SS
17 m	rd. SLTST. & MDST. w root stigmaria and burrow tubes
8 m	gy.-gn., cross-bedded, f.-m.g. SS w CGLT lenses
8 m	rd. SLTST w grn. mottle patterns, root stigmaria at top
9 m	gy., cross-bdd; cgltc. f. - m.g. SS; plant fragments abundant
28 m	rd., vy. thin bdd., SLTST, in part w stigmaria & burrow tubes interbedded w thin beds of gy. cross-bedded v.f.g. SS
2 m	lt. tan, "clean," vy. thin & thin cross-bdd. f.g. SS
8 m	gy., vy. thin cross-bdd., f.g. SS
5 m	gy., vy. thin cross-bdd., f.g. SS
57 m	rd. and grn., in part w green mottling, in part slightly calc. and with root stigmaria, SLTST and MDST
2 m	gy. & gn.-gy., cross-bdd., f.g. SS w abundant plant frags. and a few "coaly" seams
10 m	rd. SLTST and MDST

Base of Section

NOTE: Plant fragments ubiquitous in this section.
No marine fossils observed.

Use base of 2 m "clean" sandstone as datum for your stratigraphic cross-section.

Section 7

Table 9-12

Procedure I: Plotting Stratigraphic Cross-Section

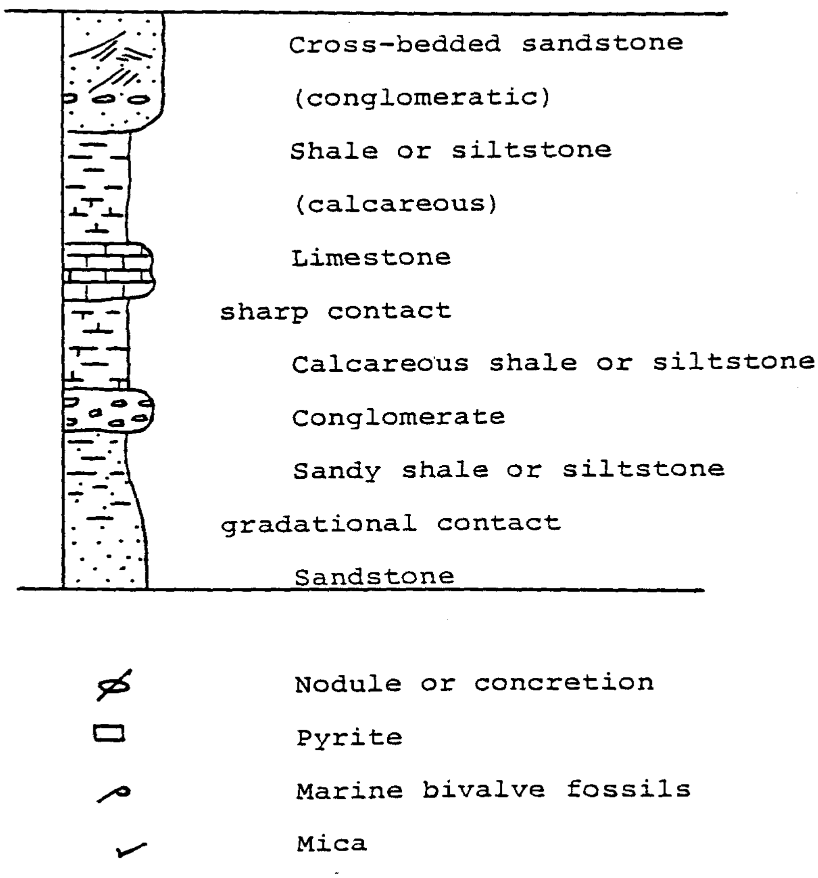
1. The cross-section should be drawn at a horizontal scale of 1 cm = 5 km and a vertical scale of 1 cm = 10 m

2. Assume that the cross-section trends East-West for a distance of 138 km.

3. The spacing between adjacent sections (running from west to east) is:

1 - 2 = 11 km	2 - 3 = 28 km	3 - 4 = 25 km
4 - 5 = 28 km	5 - 6 = 22 km	6 - 7 = 23 km

4. Plot the lithologic units for each section in relief style. (See Fig. 9-1 for the appropriate symbols.) The column should not exceed 1.5 cm in width.



Standard Stratigraphic Symbols

Figure 9-1

Procedure II: Designation of Facies

1. Study the relationships of the lithologic units that appear on your stratigraphic cross-section.

2. Using the characteristics of the alluvial facies, tidal facies, nearshore facies and offshore facies outlined in Tables 9-2 through 9-5, establish which of these are represented on your cross-section.

3. After you feel that you have worked out the spatial relationships of the sedimentary facies, draw contact lines which separate them. A color pattern for each will help to bring out the configuration of the facies.

Procedure III: Interpretation of Facies

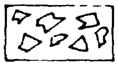
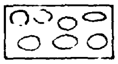
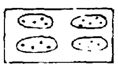
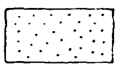
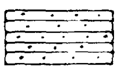
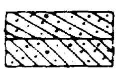
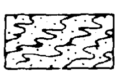
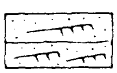
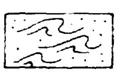
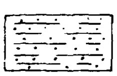
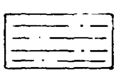
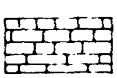
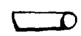
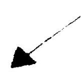
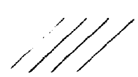
1. Using your stratigraphic cross-section, interpret the geological history of the area in terms of (a) tectonics of the source area, (b) tectonics of the depositional basin, and (c) transgression versus regression.

2. Summarize your interpretation in the space below.

AGI DATA SHEET 4.1

Symbols for Fluvial Nonmarine Sequences

Tor H. Nilsen, U.S. Geological Survey

	Breccia
	Conglomerate, clast-supported
	Conglomerate, matrix-supported
	Rip-up clasts, shale or mudstone
	Rip-up clasts, sandstone
	Sandstone, massive
	Sandstone, parallel-stratified
	Sandstone, trough cross-stratified
	Sandstone, tabular cross-stratified
	Sandstone, contorted cross-stratification
	Sandstone, ripple-marked
	Sandstone, convoluted-laminated
	Sandstone, parallel-laminated
	Siltstone
	Mudstone or shale
	Carbonate
	Paleosol
	Carbonate concretions
	Burrow, invertebrate
	Burrow, vertebrate
	Root cast
	Tree stump, in place
	Tree stump, clast
	Plant fossil
	Vertebrate fossil
	Invertebrate fossil
	Mudcracks
	Raindrop imprints
	Flute cast
	Load cast
	Scoured surface
	Paleocurrent azimuth
	Point bar sequence
	Fining-upward cycle
	Coarsening-upward cycle

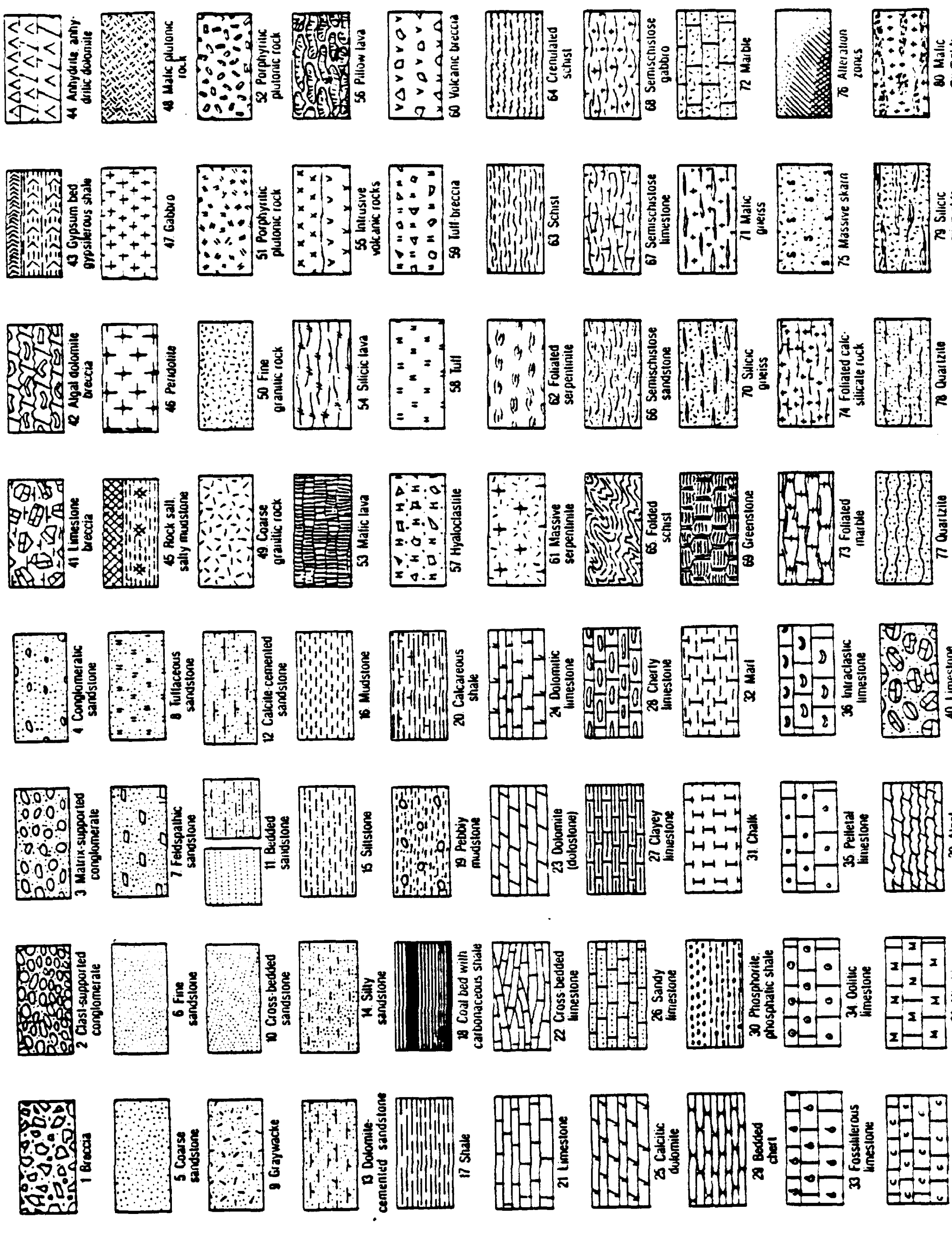
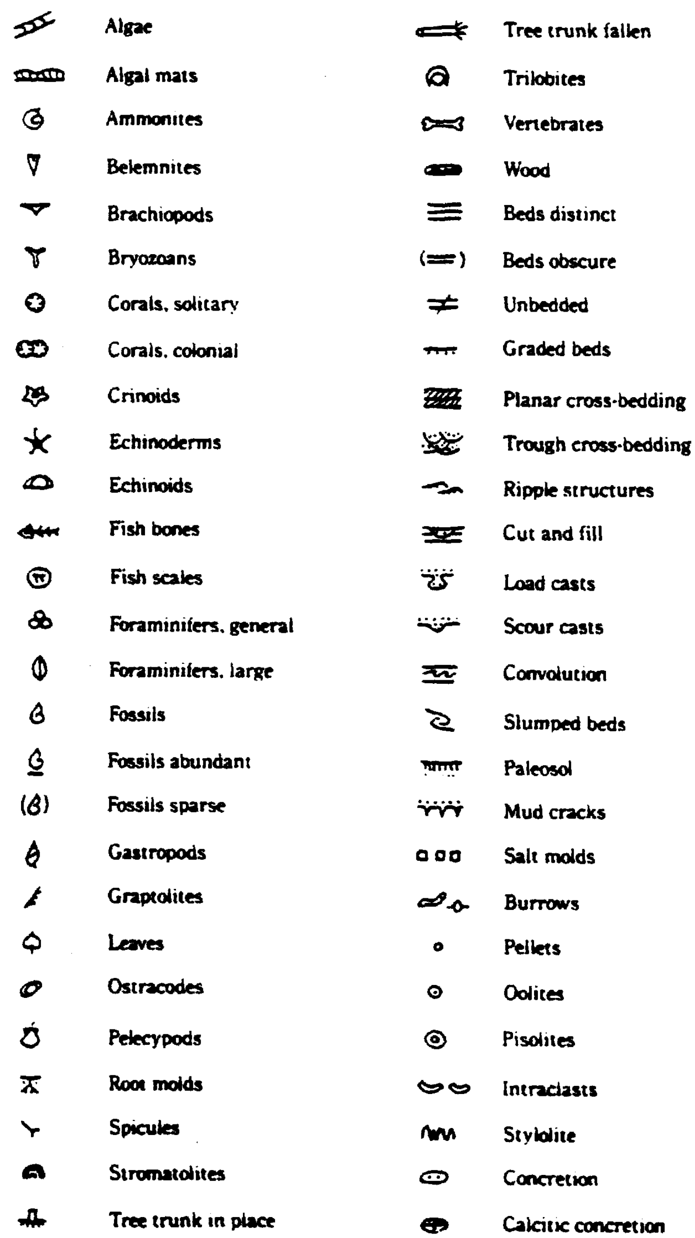


Figure 5.12. Rock patterns, fossil and structure symbols for graphic columns.
From R. R. Compton, 1985, *Geology in the Field*, Wiley, New York, Appendix 8 and 9, p. 376-378. Copyright c 1985, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.


Algae
Algal mats
Ammonites
Belemnites
Brachiopods
Bryozoans
Corals, solitary
Corals, colonial
Crinoids
Echinoderms
Echinoids
Fish bones
Fish scales
Foraminifers, general
Foraminifers, large
Fossils
Fossils abundant
Fossils sparse
Gastropods
Graptolites
Leaves
Ostracodes
Pelecypods
Root molds
Spicules
Stromatolites
Tree trunk in place
Tree trunk fallen
Trilobites
Vertebrates
Wood
Beds distinct
Beds obscure
Unbedded
Graded beds
Planar cross-bedding
Trough cross-bedding
Ripple structures
Cut and fill
Load casts
Scour casts
Convolution
Slumped beds
Paleosol
Mud cracks
Salt molds
Burrows
Pellets
Oolites
Pisolites
Intraclasts
Stylolite
Concretion
Calcitic concretion

about	abt
above	abv
abundant	abnt
aggregate	Aggr
algae, algal	Agl
amorphous	amor
amount	Amt
amphibole	Amph
angle	
angular	ang
andesite	And
anhydrite	Anhy
apparent	apr
appears	aprs
approximate	approx
aragonite	ara
argillite	Arg
Arkose	Ark
asphalt	Asph
average	Ave
bed	Bd
bedded	bdd
bedding	Bdng
bentonite	Bent
biotite	Biot
bituminous	bit
black	blk
blue	bl
boulder	Bldr
brachiopod	Brach
breccia	Bx
brown	brn
bryozoa	Bry
calcareous	calc
calcite	Calc
carbonaceous	carb
cavernous	cav
cement	Cmt
chalcedony	Chal
chalcopyrite	Cp
chalk	Chk
chert	cht
chlorite	Chl
clast, clastic	clas
clay, clayey	cly
claystone	Clst
clean	cln
clear	clr
cleavage	Clv
coarse, coarsely	c
cobble	Cbl
color	col
common	com
compact	cpct
conglomerate	Cgl
contact	Ctc
coquina	coq
covered	cov
cross-bedded	xbdd
cross-bedding	Xbdg
cross-laminated	xlam
cross-section	X sect
crystal	Xl
crystalline	xln
dark	dk
debris	deb
diameter	Diam
different	diff
disseminated	dism
dolomite	Dol
dolomitic	dol
dolostone	Dolst
elevation	Elev
equivalent	equiv
evaporite	Evap
exposure	Exp
feldspathic	feld
feldspar	Feld
fine, finely	f
fissile	fis
foraminifer	Foram
formation	Fm
fossil	Fos
fragmental	frag
friable	fri
gastropod	Gast
glauconite	Glauct
good	g
grade, graded	G
grain	gr
granite	Gran
granular	gran
graptolite	Grap
gravel	gvl
gray	gy
graywacke	Gyywke
green	gn
gypsum	Gyp
hard	hd
hematitic	hem
horizontal	horiz
hornblende	Hbld
igneous	ign
ignimbrite	Ignm
ilmenite	Ilm
impression	imp
inclusion	Incl
increase	incr
indurated	ind
interbedded	intbdd
interfingered	intfr
intrusion	Intr
invertebrate	Invrtb
iron	Fe
ironstone	Fe-st
irregular	ireg
joint	Jnt
kaolinite	Kaol
K-feldspar	Kspar
laminated	lam
large	lrg
lentil, lenticular	len
light	lt
lignite	Lig
limestone	Ls
limonite	Lim
lithologic	lith
lower	low
magnetite	Mag
marlstone	Mrlst
massive	mas
matrix	mtx
maximum	Max
medium	m
member	Mbr
metamorphic	met
mica	Mica
montmorillonite	Mont
mottled	mot
mudstone	Mdst
muscovite	Musc
no, non-	n
nodular	nod
numerous	num

Table 5.1. A list of some of the standard abbreviations used in field notes and lithologic descriptions. To avoid confusion, abbreviations for nouns are capitalized and adjectives are lower case. For additional and more complete lists refer to Mitchell and Maher (1957) and Compton (1985).

olivine	Ol	regular	reg	tabular	tab
oolite, ooid	oo	replaced	repl	temperature	T
ostracod	Ost	rhyolite	Rhy	texture	tex
		ringstraked	rngst	thick	thk
pebble	Pbl	rocks	Rx	thin	thn
pelecypod	Plcy	round, rounded	Rd	topographic	topo
pellet	pel			trace	tr
permiability	Perm	sand	sd	tuffaceous	tuf
phenocryst	Pheno	sandstone	Ss		
phosphatic	phos	saturated	sat	unconformity	Uncf
plagioclase	Plag	scattered	scat	upper	up
point	Pt	secondary	sec		
poor	p	sediment	Sed	variable	var
porosity	por	sedimentary	sed	variegated	vrtg
possible	pos	shale	Sh	vegetation	Veg
probable	prob	siliceous	sil	vertebrate	Vrtb
pyritic	py	siltstone	Slst	very	v
pyroxene	Px	small	s	volcanic	volc
pyrrhotite	Pyrr	soluble	sol	volume	Vol
		sorted	srtd		
quartz	Qz	station	Sta	wavy	wvy
quartzite	Qzt	Staurolite	Staur	weathered	wthrd
		stone	st	white	wh
radiolarian	Rad	stratigraphic	strat		
rare	rr	subangular	sbang	yellow	yel
reconnaissance	Recon	subrounded	sbrd		
red	rd	surficial	surf	zone	zn