Chapter 5 Rock Descriptions and Stratigraphic Columns

"And he said, What shall I give thee? And Jacob said ... I will pass through all thy flock to day, removing from thence all the speckeled and spotted cattle, ... and the spotted and speckeled among the goats: and of such shall be my hire. And Jacob took him rods of green poplar, and of hazel and chestnut tree; and pilled white strakes in them, ... And he set the rods which he had pilled before the flocks ... And the flock conceived before the rods, and brought forth cattle ringstraked, speckeled and spotted.

Genesis 30:27-42 King James Version

INTRODUCTION

The basic data of the stratigrapher is the measured section or logged borehole. Presented in a vertical column, the section with sediments or rocks depict their relative and/or absolute age relations, sedimentary structures, weathering profile, rock type, type of contact and other important information. This graphical presentation provides a useful framework to better understand individual sedimentary units and their relationships to bounding strata. Ultimately, this data base allows for regional sedimentary correlations and the interpretation of depositional environments. Care must be taken to compile and present accurate information in such sections and the use of a particular section determines the scale and methods used in measuring.

Because the data base for the measured section and all subsequent interpretations are based on the original field rock descriptions, we will first discuss and provide exercises designed to help you learn to correctly identify and describe a variety of types of sedimentary rocks. In the last part of the chapter you will learn how to use these descriptions of sedimentary rocks and sedimentary structures to measure, draft and correlate stratigraphic sections.

PRINCIPLES AND METHODS

Rock Descriptions

Before beginning the process of describing rocks at an outcrop or from borehole cuttings or core, several questions need to be asked. First, "what is the scope of the study?" If, for instance, the study is aimed at a quick reconnaissance of a large sedimentary basin in a short period of time, it may be most efficient to spend only an hour or so at an outcrop, noting only the most salient features such as bedding, lithology, composition and fossils. If, on the other hand, the stratigrapher wishes to make detailed reconstructions of depositional environments at a limited number of places, with no time constraints, description can be considerably more detailed. In this chapter, we present the latter approach and leave it to the individual geologist to abbreviate descriptions in reconnaissance surveys.

The second question to ask at the outcrop is "in what type of packages are the rocks arranged?" In other words, what defines the bedding. Such features as fining upward sequences, cyclic sandstone-shale-limestone deposits, interbedded evaporites and red mudstone, or any type of repeating layers should be determined. Recognition of these packages will add logic and organization to note taking, section measuring, and the construction of stratigraphic columns. Often, components of the largest packages may themselves be composed of smaller units. For example, the red mudstone in an evaporite-mudstone sequence may actually contain a number of thin graded beds of fine-grained sand within the mud. The best way to deal with the "packages within packages" problem is to start by describing the largest recognizable units and then work down to those of the next order, and so on.

When measuring a stratigraphic section it is important to make observations before, during and after the actual measurements of the unit thicknesses. First impressions at an outcrop can be important and taking the time to record them is usually worth the effort. This general description can be used to supplement specific details and small-scale observations of rock type, sedimentary structures, textures, grain size fossils, and others noted during the actual measuring, It is also prudent to summarize observations after section measuring is complete to distill the information, identify patterns and elucidate packages. The following checklist identifies the types of information that should be included in field description of sedimentary rocks and for measuring sections. This list can be modified and tailored to meet the needs of each individual study.

1. Name and location of section
   a. Use a geographic and formational designation, for example: "Section of Golden Spike Conglomerate at Gold Creek, Montana.

   b. Give age of units if known.

   c. Give a precise location of the measured section including township, range and section, latitude and longitude or coordinates of the grid system used in the area of the study. Also include topographic features and distance to known geographic features.

   d. Note the detailed path of the measured section, relating it to obvious topographic or geographic features.

   e. If possible, plot the location and path of the section on a topographic base map. Be certain to note the name of the quadrangle used and its scale.

2. Method used for measuring.
   a. Note the method you used. E.g., Jacob's staff, measuring tape, surveying, pacing, etc.

   b. Make sure to record any changes in method during measuring, for example, you may have started with a Jacob's staff but estimated thickness after half way through the section.

   c. Record the direction of section measuring, upsection or downsection, and the reasons for this determination.

3. Name and date.
   a. List the name(s) of all geologists working with you on the section.

   b. Give the date, weather and time of start and end of the field work. List any problems or conditions that may affect your descriptions and interpretations.

4. Description of the outcrop.
   a. The degree and type of exposure.

   b. Type of cover, talus, vegetation, etc, and percent coverage.

c. Note the changes through the section.

5. Description of rocks.

a. Start with largest features first, external shape and size of beds, and relative percentage of rock types.

b. Progress to more detail, internal bedding (laminae) and structures, textures and color.

c. List relative percentages and ranges of features when possible.

d. Thicknesses of measured units and details of contacts between units.
e. Construct a field column, detailing rock types and structures.

6. Interpretation.

a. Separate your interpretation from the description.

b. Tie your comments to specific features, for example: "... the thin, horizontal laminae, containing faint ripple cross laminae appear to be eolian translatant strata like Hunter described in the Navajo Fm ..."

c. At the end of the day summarize your feelings and thoughts about the section.

7. Format.

a. Devise a format that is concise, neat and organized.

b. An example is given in Figure 5.1, where interpretations, sample numbers and thicknesses are written on the left page of the notebook and descriptions and a field column on the right page.

c. Keep all pertinent information glued in your notebook, including a rock-description checklist (following), percentage charts (Fig. 3.16) and classification schemes.

CLASSIFICATIONS

There are numerous classification schemes for sedimentary rocks and many are claimed to be better than others. Ideally, it would be nice if all classifications were as widely accepted as textural terminology, but this is not likely to occur. Furthermore, many classifications and names emphasize different attributes of the rock so that the proper scheme should be chosen depending on the rock types and emphasis of each study.

We feel that any good classification scheme should be logical, descriptive, and convey the essential points to all geologists, even to those who prefer different schemes. In this vein, we suggest the terminology presented in Figures 5.2 - 5.6 for field classification of sedimentary rocks. More specific classifications (referenced at the end of this chapter) can be used if needed.

Following is a checklist for the description of sedimentary rocks and a list of terms useful for identifying important constituents of carbonate rocks. This checklist actually fits under category #5, "Description of Rocks", in the previous list. Your descriptions should generally follow a paragraph format rather than a step by step procedure as indicated in the checklist. The checklist is included here so that you can organize your written descriptions so that they all follow the same order. Use of a checklist will also ensure that you don't leave out important information for some of the samples.

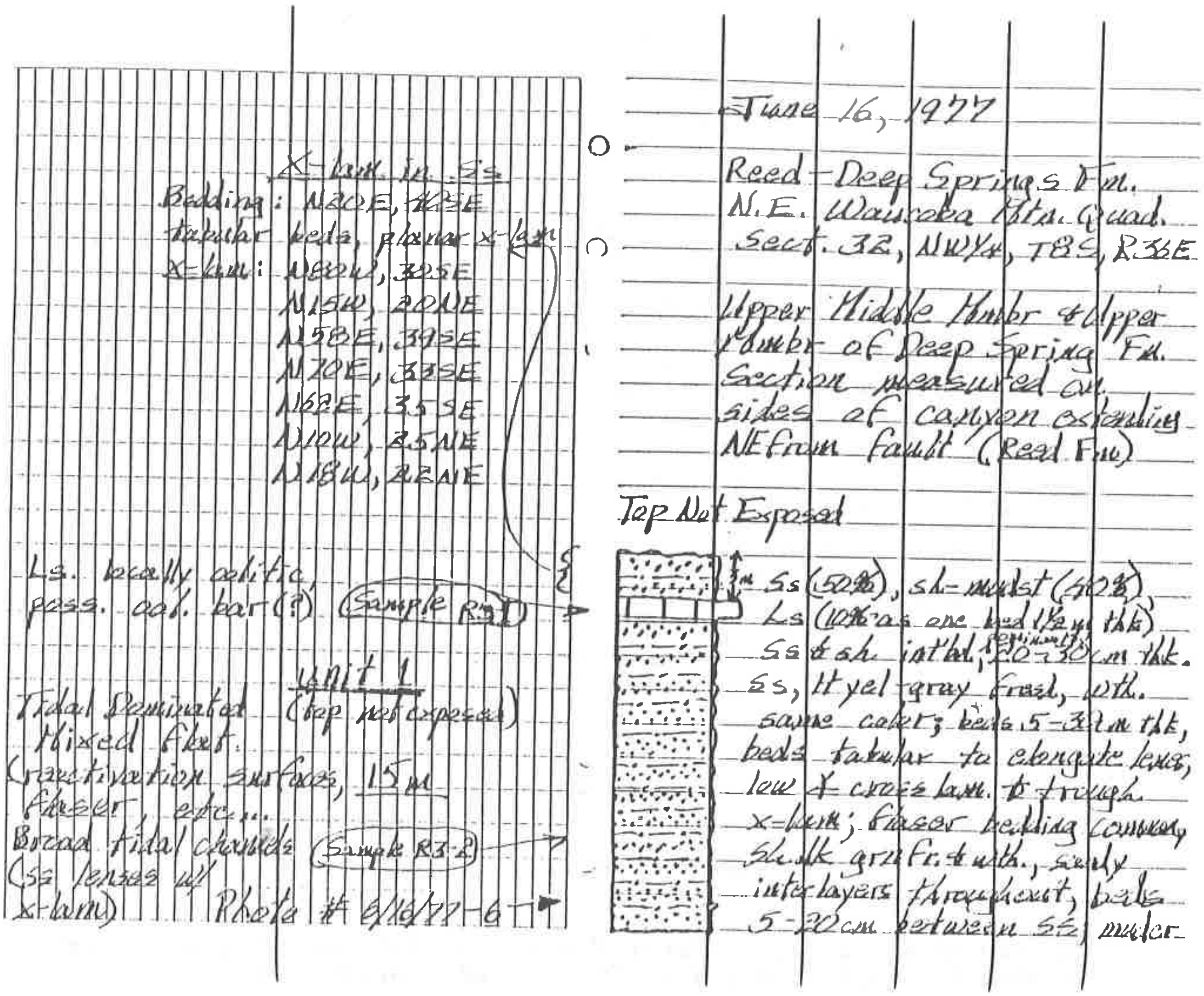

Figure 5.1. Sample notebook pages from a typical field notebook.

CHECKLIST FOR THE DESCRIPTION OF SEDIMENTARY ROCKS

1. Type of rock (include distribution and percentage of each type present in the outcrop)

2. Color (rock color chart is useful)
   a) fresh
   b) weathered
   c) wet
   d) color distribution (homogeneous, banded, mottled, etc.)

3. Nature of outcrop
   a) topographic expression of unit (cliff, slope, etc.)
   b) quality of exposure
   c) weathering products (soil color)
   d) vegetation, type and amount of cover

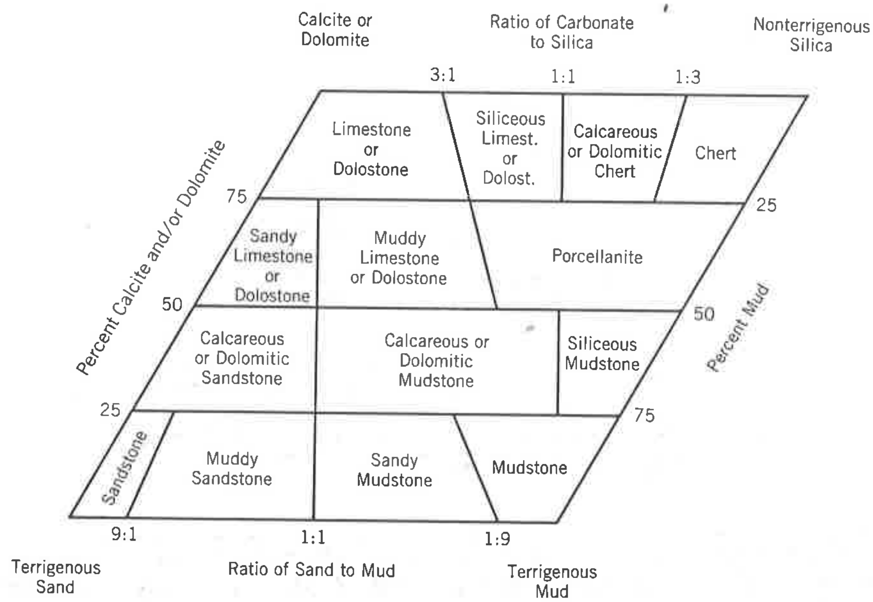

Figure 5.2. General compositional classification of sedimentary rocks composed of terrigenous sand, terrigenous mud, carbonate and nonterrigenous silica. From W. J. Fritz and J. N. Moore, 1988, *Basics of Physical Stratigraphy and Sedimentology*, Wiley, New York, Fig. 2.4, p. 48. Copyright c 1988. Reprinted by permission of John Wiley & Sons, Inc.

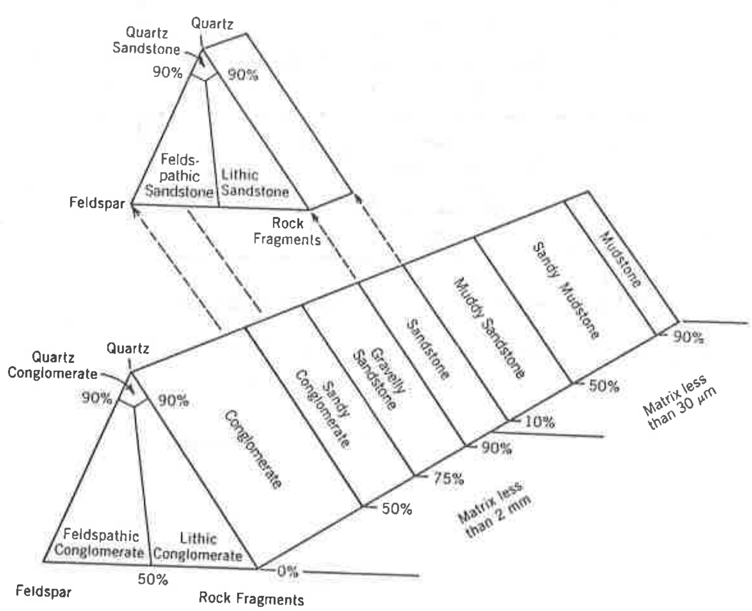

Figure 5.3. Classification of sedimentary rocks with clay to boulders composed of quartz, feldspar, and lithic rock fragments. From W. J. Fritz and J. N. Moore, 1988, *Basics of Physical Stratigraphy and Sedimentology*, Wiley, New York, Fig. 2.5, p. 50. Copyright c 1988. Reprinted by permission of John Wiley & Sons, Inc.

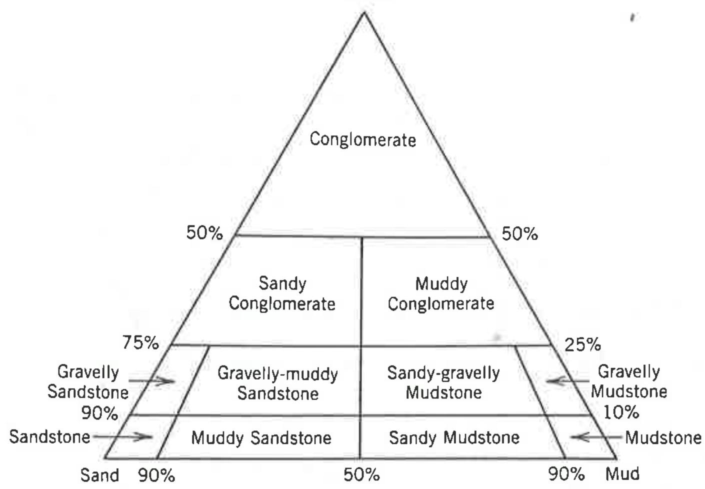

Figure 5.4. Classification of conglomerates based on percentages of gravel, sand and mud. From W. J. Fritz and J. N. Moore, 1988, *Basics of Physical Stratigraphy and Sedimentology*, Wiley, New York, Fig. 2.14, p. 57. Copyright c 1988. Reprinted by permission of John Wiley & Sons, Inc.

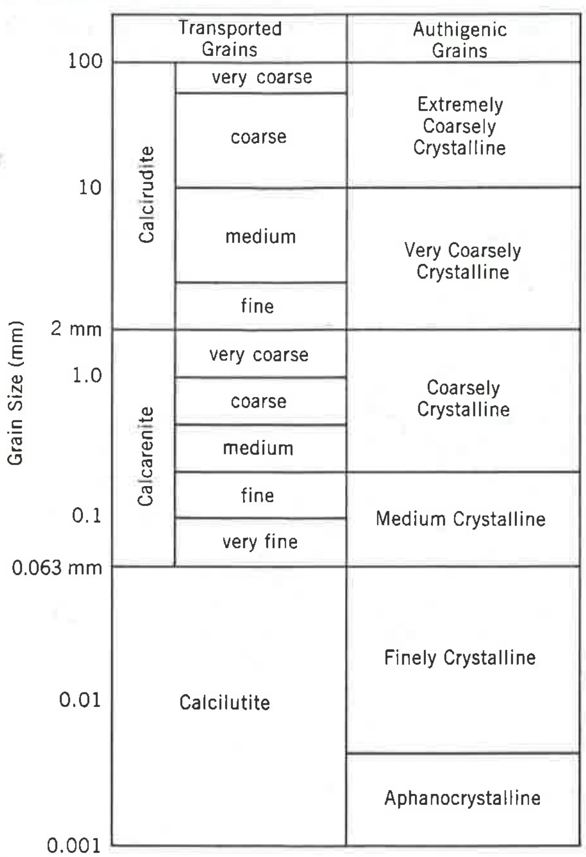

Figure 5.5. Classification of carbonate transported and authigenic grains based on grain size. From W. J. Fritz and J. N. Moore, 1988, *Basics of Physical Stratigraphy and Sedimentology*, Wiley, New York, Fig. 2.31, p. 75. Copyright c 1988. Reprinted by permission of John Wiley & Sons, Inc.

<table>
<tr><td>Dominant Grain Size</td><td colspan="3">SAND</td><td colspan="3">MUD</td></tr>
<tr><td>Size Terms</td><td colspan="3">Calcarenite</td><td colspan="3">Calcilutite</td></tr>
<tr><td>Terrigenous Equivalents</td><td>Sandstone</td><td colspan="2">Muddy Sandstone</td><td colspan="2">Sandy Mudstone</td><td>Mudstone</td></tr>
<tr><td>Modified from Folk (1959)</td><td colspan="2">Sparite</td><td>Micritic Sparite</td><td>Sparry Micrite</td><td colspan="2">Micrite</td></tr>
<tr><td>Modified from Dunham (1962)</td><td>Grain-stone</td><td colspan="2">Packstone</td><td colspan="2">Wackestone</td><td>Calc-mudstone</td></tr>
</table>

0 10 20 30 40 50 60 70 80 90 100

Percent Carbonate Mud

Figure 5.6. Classification of carbonate rocks. This figure should be viewed as a translation box that compares terrigeneous terms with those used in carbonate classifications by Folk (1959) and Dunham (1962). From W. J. Fritz and J. N. Moore, 1988, *Basics of Physical Stratigraphy and Sedimentology*, Wiley, New York, Fig. 2.35, p. 79.

4. Form of unit as a whole
   a) tabular, wedge, lens, etc.
   b) thickness
   c) dimensions

5. Primary structures
   a) character of base of unit (sharp, gradational, even, etc.)
   b) stratification (how shown - texture, composition, grain size)
   c) type of stratification (parallel, cross-stratified, irregular, etc.)
   d) thickness (give range and average - be specific)
   e) succession (alternating, rhythmic, etc.)
   f) type of structures (ripples, mudcracks, cross beds, etc., etc.)

6. Secondary structures
   a) fissility
   b) fractures, cleavage, joints
   c) concretions or nodules
   d) slump, load and other soft-sediment deformational features

7. Texture
   a) grain size - include range and average, noting variations
   b) sorting - notice variations within the unit
   c) grain shape
   d) surface texture of grains
   e) type or composition of grains

8. Composition (include percentages if more than one)
   a) mineral grains
   b) rocks and rock fragments
   c) matrix
   d) organic material

e) ooids, pisolites, intraclasts, bioclasts, etc.
f) cement
g) clasts

9. Induration - degree and type of cement

10. Nature of contacts between units
   a) sharp or gradational - give scale
   b) conformity or type of unconformity
   c) criteria for recognizing contact

11. Fossils
   a) kind
   b) abundance
   c) preservation
   d) position and orientation
   e) include traces

COMMON TERMS IN CARBONATE SEDIMENTS

Orthochemical constituents

1) Micrite - lime mud, grain 1-4 micrometers in diameter, probably from disintegration of organisms. Rocks bound by micrite appear dull on a fresh break.

2) Sparry calcite - clear compared to micrite, crystals much larger than micrite, usually occurs as pore filling calcium carbonate cement. Rocks cemented with sparry calcite have many light-reflecting surfaces on a fresh break.

Allochemical constituents

1) Intraclasts ("intra") - Pieces of weakly consolidated carbonate sediment that have been torn up, transported and redeposited. Carbonates containing intraclasts are sometimes called intraformational or flat-pebble conglomerates.

2) Ooids ("oo") - Small spherical objects with concentric or radial laminae ranging in size from 0.1 - 1.0 mm in diameter. Ooids usually contain a central nucleus and are commonly associated with shallow, turbulent water.

3) Pisolites - similar to ooids but larger than 1.0 mm and generally with a much larger nucleus that makes up most of the mass of the grain.

4) Oncolites - Roundish objects that are algal in origin. They are the lithified equivalent of a modern algal biscuit. Algal layers are overlapping and each layer does not generally surround the entire sphere.

5) Pelloids ("pel") - Small roundish or rod-shaped micrite bodies ranging from about 0.3 - 2 mm in size. Formed by feeding activities as feeding and fecal pellets.

6) Stromatolites - Blue-green algal mats with various shapes dependent on environments. See your text or Figure 4.12 for a detailed classification of stromatolites based on shape.

MEASURING SECTIONS

Stratigraphic sections may be measured in various ways depending on the scope of the study and the amount of detail desired by the stratigrapher. The most "broad-brush" approach may be employed in cases where the only desired information is the thickness of a particular unit. It is often possible to calculate these thicknesses from maps and air photos without leaving the office. The precision of this method limits the resulting data. Figure 5.7. presents various geometric cases and how thicknesses are calculated.

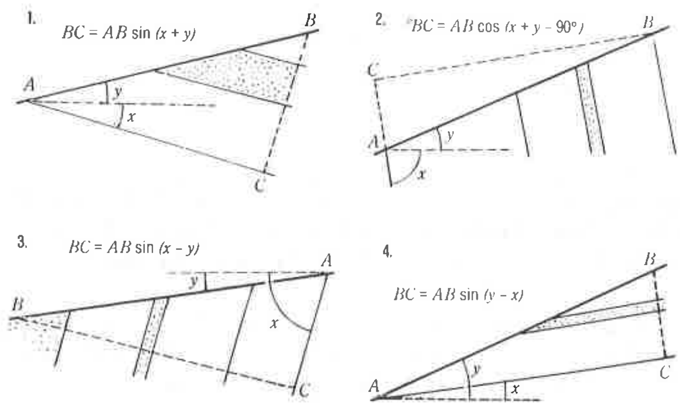

Figure 5.7. Formulas used for determining the true thickness of rock layers in a variety of situations. From R. R. Compton, 1985, *Geology in the Field*, Wiley, New York, Fig. 11.12, p. 234. Copyright c 1985, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

A more precise method of measuring thicknesses in the field is the pace-compass traverse. This method offers a compromise between the broad-brush approach above and the more time consuming methods described below. The pace-compass traverse is especially suited to stretches of winding road trending roughly across strike. The theory behind the pace-compass traverse is to establish and plot stations by walking increments of known distance (calculated from an individual's pace) in known directions (read from a compass). During the traverse, the geologist plots lithologic contacts and strikes and dips on a map. When the traverse is completed, the end product should resemble a geologic trip map with the line of traverse superimposed (Fig. 5.8). Consult a general field manual such as Compton (1985) for more details on how to use this method.

Probably the most common method of measuring sections is with the Jacob's staff. The Jacob's staff offers the best compromise between accuracy and time efficiency for most stratigraphic studies. Figure 5.9 shows how the staff is used. One advantage of this method is that the staff is designed so as to account for structural dips right on the spot. In other words, by using a protractor and sighting device, it is possible to measure true thicknesses without bothering with trigonometric calculations. Often, it is worth the time to spend the first hours of a study measuring the section without writing detailed descriptions. This way, if tape or paint is applied at desired intervals (e.g., every meter), the cumbersome staff can be set aside and the stratigrapher can concentrate on rock descriptions.

Another common method of measuring a section is the Brunton and Tape method, illustrated in Figure 5.10. This method requires at least two people and is considerably slower than the Jacob's staff method. Also, corrections for slope and transect direction make calculation of real thickness time consuming (see Fig. 5.7). Other methods employed where a high degree of accuracy is required are the Transit and Tape method and the Plane Table and Alidade method. These are essentially precision surveying techniques used when hand-held Brunton measurements are too

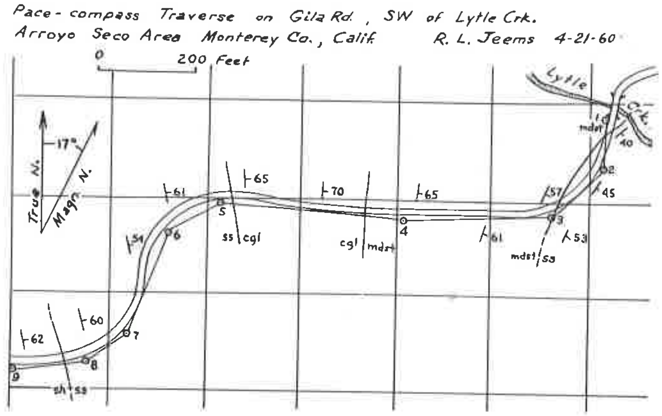

Figure 5.8. Strip map made from a traverse. From R. R. Compton, 1962, *Manual of Field Geology*, Wiley, New York, Fig. 3-2, p. 40. Copyright c 1962, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

inaccurate, such as in planning detailed development of a mine or quarry operation. These methods supply very accurate information at the cost of high labor and time expenditures. Field manuals such as Compton (1985) give the details of these methods.

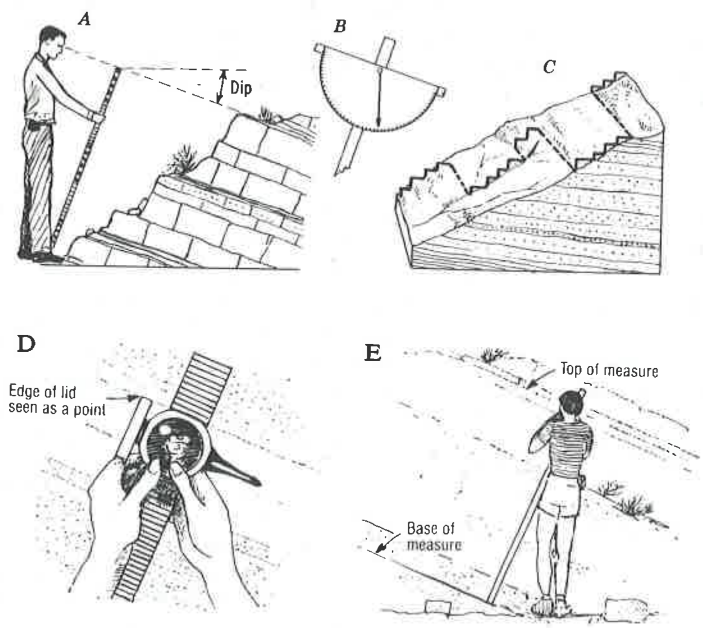

Figure 5.9. Use of Jacob's staff. (A) Method of holding and sighting with a Jacob staff at an outcrop. (B) Sighting bar and simple clinometer made from a protractor. (C) Stepwise traverse of a section. (D) Method of holding Brunton compass along staff and sighting with the lid. (E) Position for taking a measurement. From R. R. Compton, 1962, *Manual of Field Geology*, Wiley, New York, Fig. 12-18, p. 237. Copyright c 1962, John Wiley & Sons, Inc. and R. R. Compton, 1985, *Geology in the Field*, Wiley, New York, Fig. 11-9, p. 232. Copyright c 1985, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

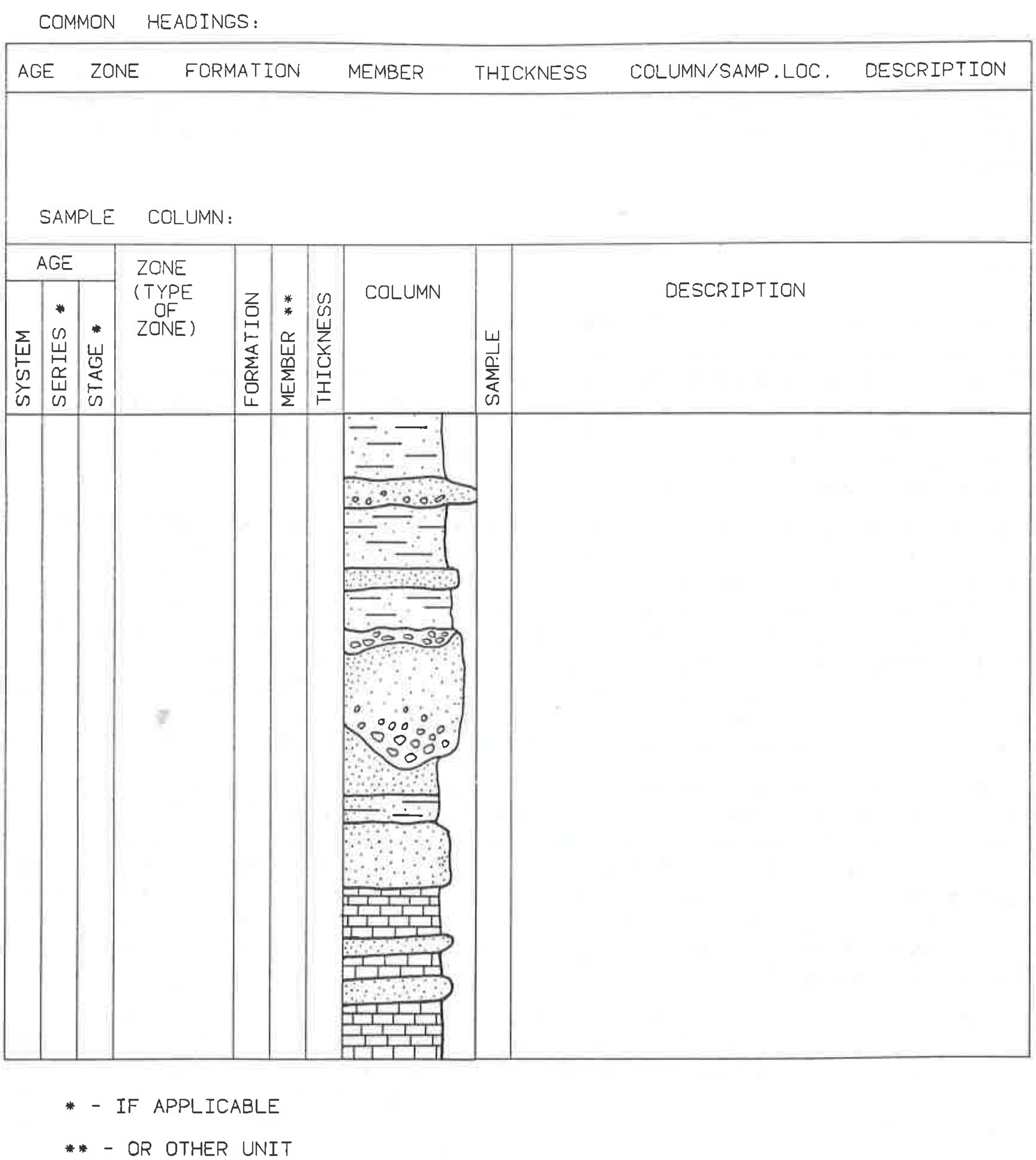

Figure 5.11. General stratigraphic column format. Use or exclusion of particular headings is dependent on purpose of the study. A blank copy of this form is included as Data Collection For 5.1.

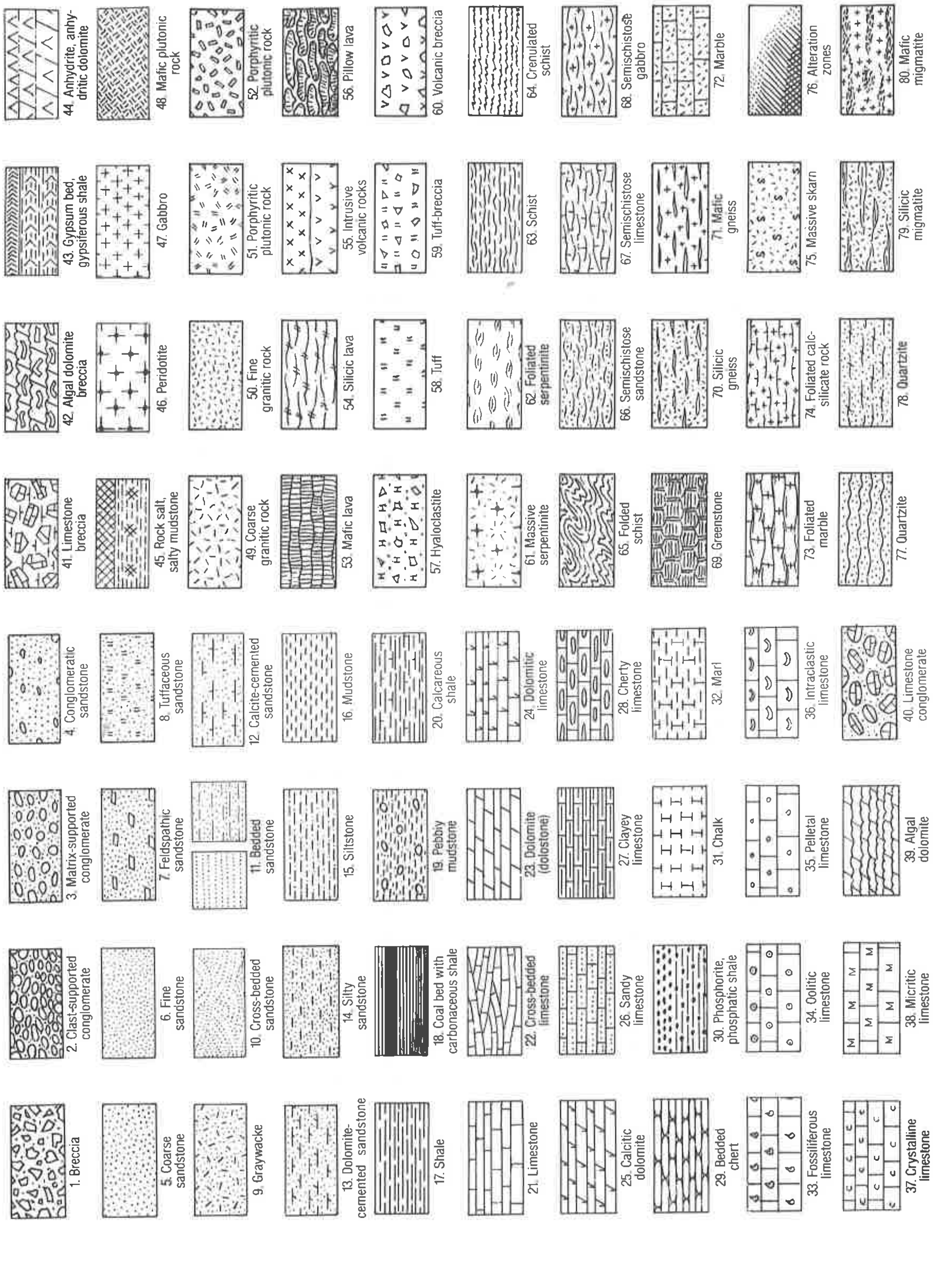

Figure 5.12. Rock patterns, fossil and structure symbols for graphic columns. From R. R. Compton, 1985, *Geology in the Field*, Wiley, New York, Appendix 8 and 9, p. 376-378. Copyright c 1985, John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.

Figure 5.12. Continued.

about	abt	cobble	Cbl	hard	hd
above	abv	color	col	hematitic	hem
abundant	abnt	common	com	horizontal	horiz
aggregate	Aggr	compact	cpct	hornblende	Hbld
algae, algal	Agl	conglomerate	Cgl		
amorphous	amor	contact	Ctc	igneous	ign
amount	Amt	coquina	coq	ignimbrite	Ignm
amphibole	Amph	covered	cov	ilmenite	Ilm
angle		cross-bedded	xbdd	impression	imp
angular	ang	cross-bedding	Xbdg	inclusion	Incl
andesite	And	cross-laminated	xlam	increase	incr
anhydrite	Anhy	cross-section	X sect	indurated	ind
apparent	apr	crystal	Xl	interbedded	intbdd
appears	aprs	crystalline	xln	interfingered	intfr
approximate	approx			intrusion	Intr
aragonite	ara	dark	dk	invertebrate	Invrtb
argillite	Arg	debris	deb	iron	Fe
Arkose	Ark	diameter	Diam	ironstone	Fe-st
asphalt	Asph	different	diff	irregular	ireg
average	Ave	disseminated	dism		
		dolomite	Dol	joint	Jnt
bed	Bd	dolomitic	dol		
bedded	bdd	dolostone	Dolst	kaolinite	Kaol
bedding	Bdng			K-feldspar	Kspar
bentonite	Bent	elevation	Elev		
biotite	Biot	equivalent	equiv	laminated	lam
bituminous	bit	evaporite	Evap	large	lrg
black	blk	exposure	Exp	lentil, lenticular	len
blue	bl			light	lt
boulder	Bldr	feldspathic	feld	lignite	Lig
brachiopod	Brach	feldspar	Feld	limestone	Ls
breccia	Bx	fine, finely	f	limonite	Lim
brown	brn	fissile	fis	lithologic	lith
bryozoa	Bry	foraminifer	Foram	lower	low
		formation	Fm		
calcareous	calc	fossil	Fos	magnetite	Mag
calcite	Calc	fragmental	frag	marlstone	Mrlst
carbonaceous	carb	friable	fri	massive	mas
cavernous	cav			matrix	mtx
cement	Cmt	gastropod	Gast	maximum	Max
chalcedony	Chal	glauconite	Glauct	medium	m
chalcopyrite	Cp	good	g	member	Mbr
chalk	Chk	grade, graded	G	metamorphic	met
chert	cht	grain	gr	mica	Mica
chlorite	Chl	granite	Gran	montmorillonite	Mont
clast, clastic	clas	granular	gran	mottled	mot
clay, clayey	cly	graptolite	Grap	mudstone	Mdst
claystone	Clst	gravel	gvl	muscovite	Musc
clean	cln	gray	gy		
clear	clr	graywacke	Gyywke	no, non-	n
cleavage	Clv	green	gn	nodular	nod
coarse, coarsely	c	gypsum	Gyp	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
oolite, ooid	oo
ostracod	Ost
pebble	Pbl
pelecypod	Plcy
pellet	pel
permiability	Perm
phenocryst	Pheno
phosphatic	phos
plagioclase	Plag
point	Pt
poor	p
porosity	por
possible	pos
probable	prob
pyritic	py
pyroxene	Px
pyrrhotite	Pyrr
quartz	Qz
quartzite	Qzt
radiolarian	Rad
rare	rr
reconnaissance	Recon
red	rd
regular	reg
replaced	repl
rhyolite	Rhy
ringstraked	rngst
rocks	Rx
round, rounded	Rd
sand	sd
sandstone	Ss
saturated	sat
scattered	scat
secondary	sec
sediment	Sed
sedimentary	sed
shale	Sh
siliceous	sil
siltstone	Slst
small	s
soluble	sol
sorted	srtd
station	Sta
Staurolite	Staur
stone	st
stratigraphic	strat
subangular	sbang
subrounded	sbrd
surficial	surf
tabular	tab
temperature	T
texture	tex
thick	thk
thin	thn
topographic	topo
trace	tr
tuffaceous	tuf
unconformity	Uncf
upper	up
variable	var
variegated	vrtg
vegetation	Veg
vertebrate	Vrtb
very	v
volcanic	volc
volume	Vol
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weathered	wthrd
white	wh
yellow	yel
zone	zn

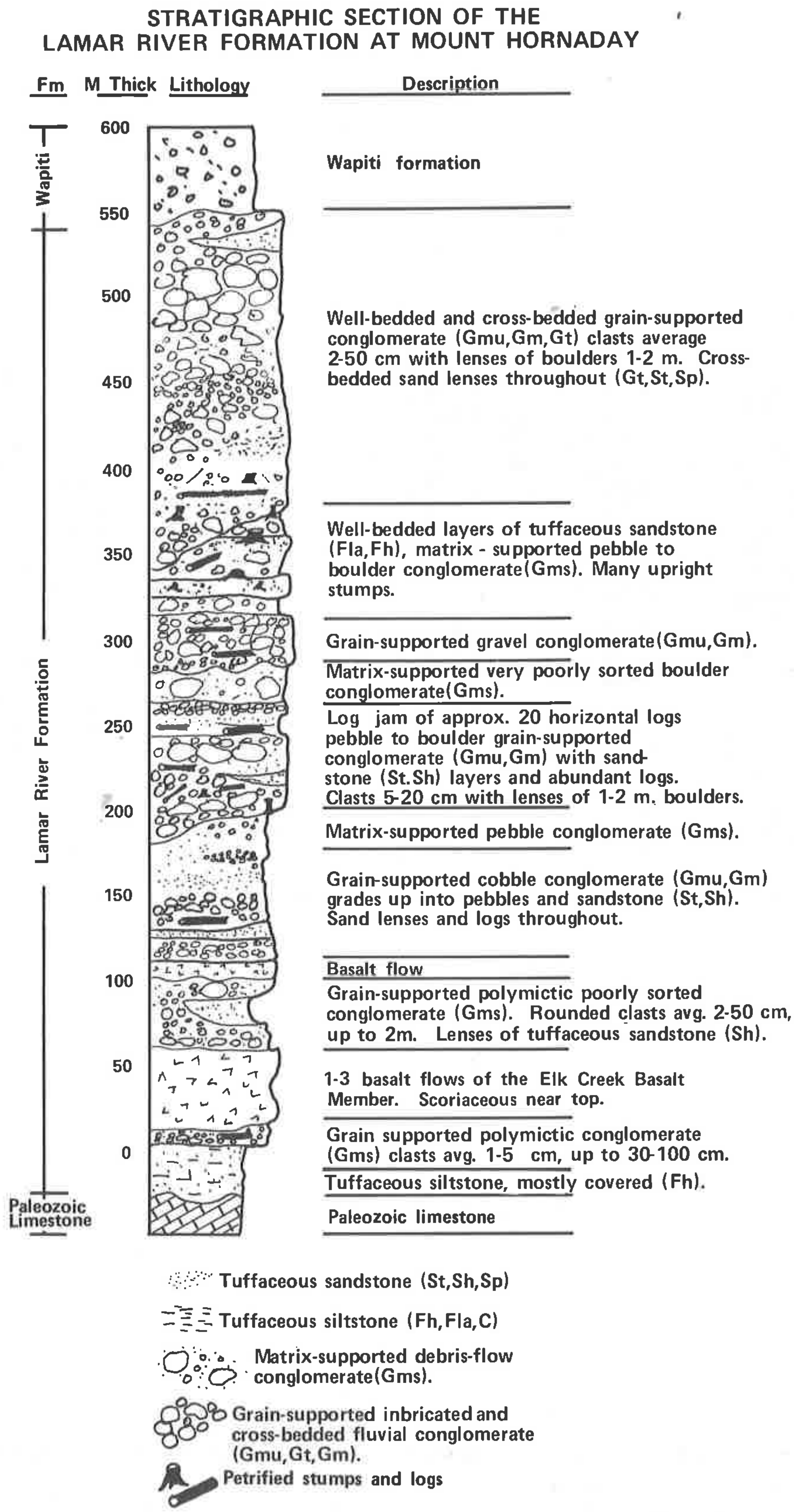


Figure 5.13. Example of a stratigraphic column.

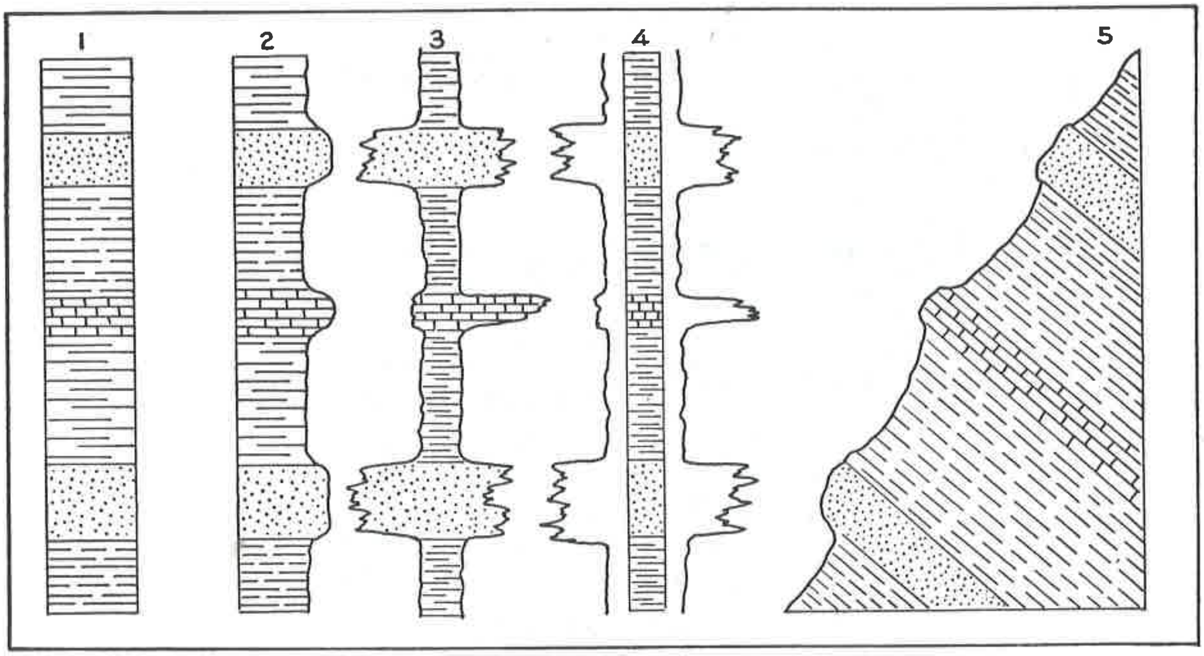


Figure 5.14. Examples of stratigraphic columns. 1) shows a drafted column with no weathering profile, 2) includes a graphic representation of the resistance of the units, 3) and 4) illustrate how sections can be drafted on the record of electric well logs and 5) is a section of the outcrop view of the rocks. From *Graphic Problems in Petroleum Geology* by L. W. LeRoy and J. W. Low. Copyright 1954 by Harper & Row, Publishers, Inc., Fig. 11, p. 36. Reprinted by permission of the publisher.

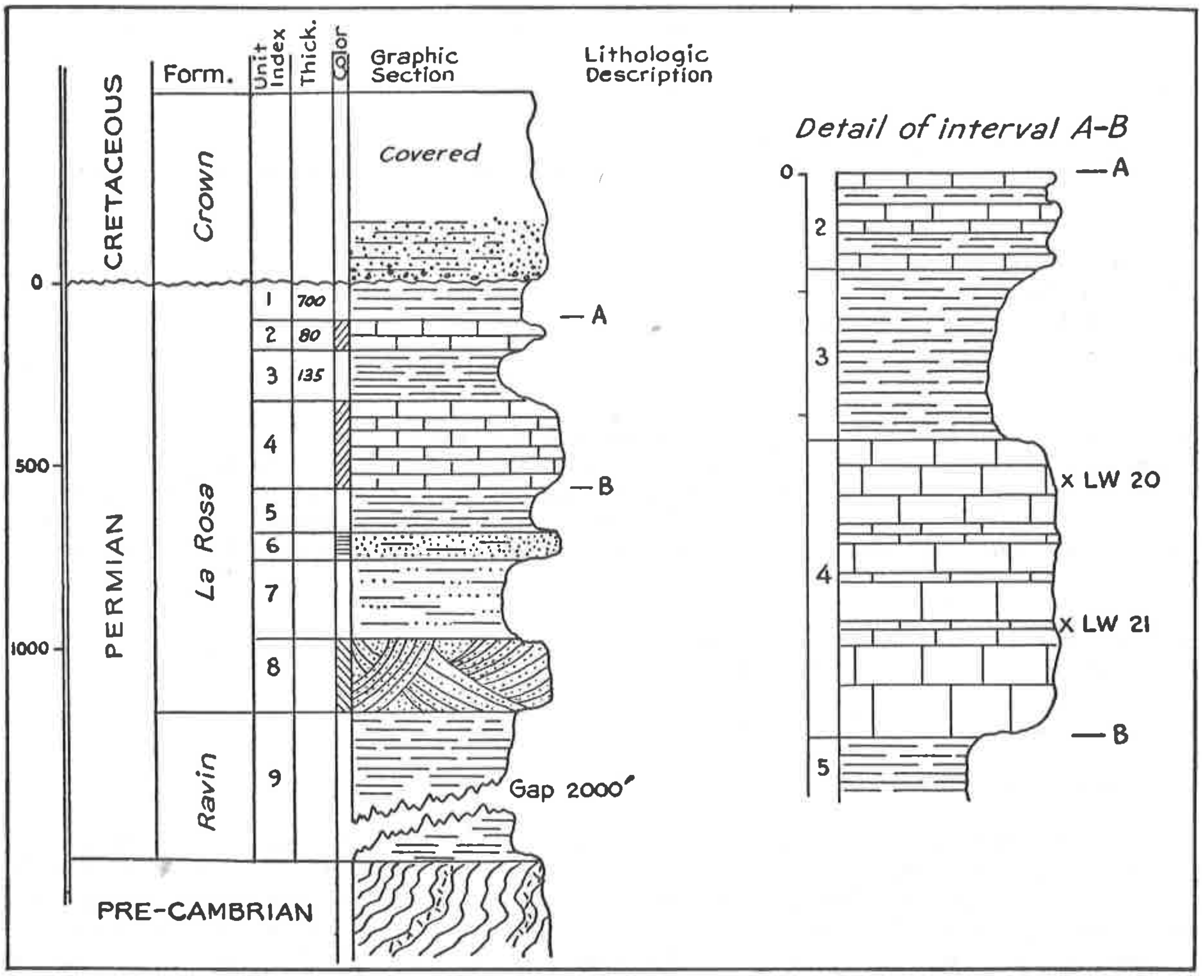


Figure 5.15. Example of a drafted columnar section. From *Graphic Problems in Petroleum Geology* by L. W. LeRoy and J. W. Low. Copyright 1954 by Harper & Row, Publishers, Inc., Fig. 11, p. 36. Reprinted by permission of the publisher.

OUTSIDE READING

General sedimentary rock identification and classification

Bathurst (1971); Blatt and others (1980); Blatt (1982); Dunham (1962); Folk (1959, 1962, 1974); Krynine (1948); Murray (1981); Pettijohn (1975); Scholle and Spearing (1982); Scholle and others (1983); Tucker (1981, 1982).

Laboaratory reference guides

Adams and others (1984); Greensmith (1978); Scholle (1978, 1979); Welton (1984).

Measured sections, correlation and field work

Compton (1962, 1985).

EXERCISES FOR CHAPTER 5

Exercise 5.1 Classification and sedimentary rock description

This laboratory exercise is designed to illustrate a wide variety of sedimentary rock types and to teach you workable names for them. For each specimen you should complete the following:

1. An accurate sketch with a scale bar
2. A detailed description
3. A single name (no more than five words)
4. A brief interpretation.

As a minimum you should complete the following number of descriptions. Remember you are responsible for describing a wide variety of sedimentary rock types, not just the ones that you choose to formally describe. Group descriptions in your notebook according to rock type. Following the descriptions for each rock type (i.e. sandstones, conglomerates, siltstones, etc.). Write a short paragraph that describes the range of textures and variations included within that type.

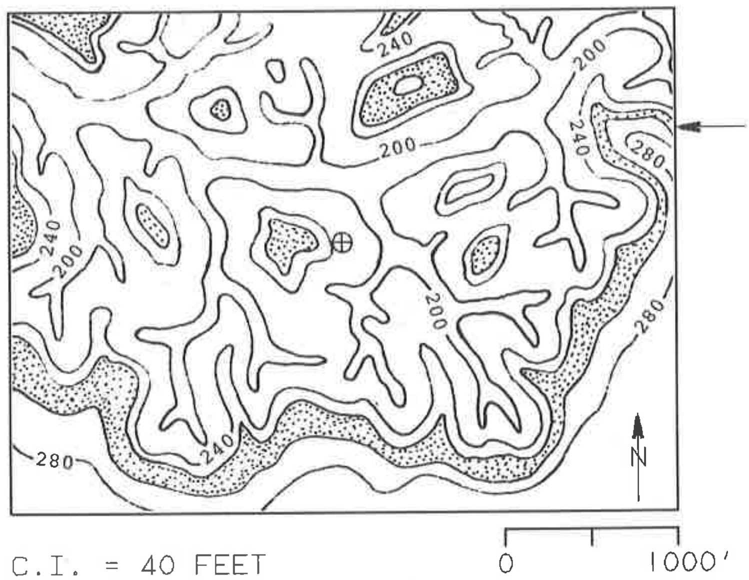
Conglomerates .... 3 descriptions
Sandstones .... 5 descriptions
Mudrocks .... 3 descriptions
Limestones .... 5 descriptions
Misc. (volcaniclastic, coal,
evaporites, phosphorites, etc.) ..... 5 descriptions

For your descriptions use a checklist such as the one in the beginning of the chapter. Your descriptions should generally follow a paragraph format rather than a step by step procedure as indicated in the checklist. The checklist is included in this chapter so that you can organize your written descriptions in the same order. Use of a checklist will also ensure that you do not leave out important information for some of the samples. Also, refer to the classification schemes in Figures 5.2 - 5.6. As an aid to understanding some of the more difficult specimens, you may also want to look through some of the petrographic texts listed in the section on Outside Reading for hints.

Exercise 5.2

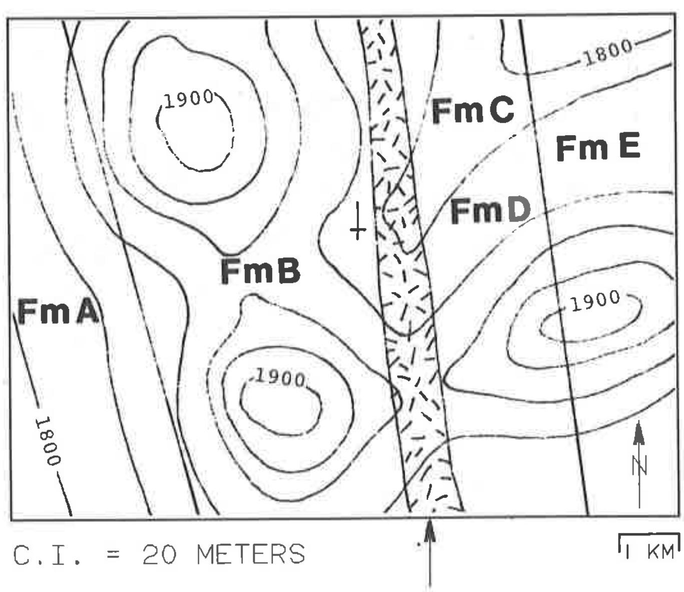
For the following maps, determine the thickness of the unit marked by the arrow. If the unit varies in thickness along the strike, calculate the range in values.

A.



C.I. = 40 FEET

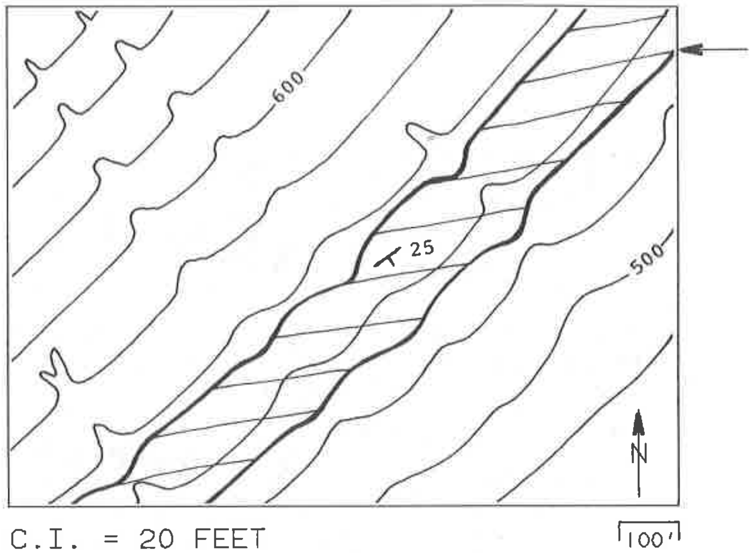
B.



C.I. = 20 METERS

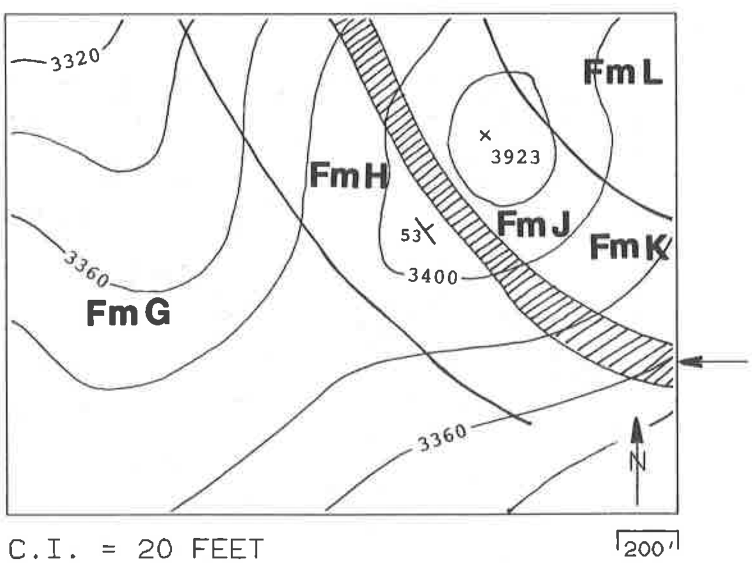
EX 5.2 - CONT.

C.



C.I. = 20 FEET

D.



C.I. = 20 FEET

Exercise 5.3 Use of Field Notes to Draft a Section

Your colleague at ACME Exploration was just fired; appears that he took liberties with the travel budget. The company received a package from him, postmarked in Belize, that contained his field notebook. As his replacement, you have been assigned to transfer his field notes into neat stratigraphic columns for presentation to management. Using his data, which unfortunately is not as great as his accounts payable, neatly draft and label two columns, following the format presented above. You will need to reorganize his data and include what seems important for the description.

Field Notes #1

Date: 1 April 84. Location: Miller's Quarry, near Frijole, El Cerito County, New Mexico. Measured section using Jacob's staff, of Cretaceous Frijole Formation; approximately 120 m thick, starting in lower part of formation; top and bottom not exposed. Weather clear and hot. Excellent exposures in walls of the quarry.

0-31m: Black, clay-rich mudstone, with thin (3-12cm) sandstone interlayers. Sandstone (approx. 10%) mostly fine-grained, contains climbing ripples laminae, and have sharp bases and graded tops; local flute marks on base. Mudstone planar laminated to moderately bioturbated, mostly structureless and weathering into fissile shale. Contact with unit above gradational over several meters.

31-74m: Interbedded sandstone (40%) and mudstone (60%), sandstone increasing upwards. Sandstone light brownish gray to brown have sharp bases and contain low-angle, undulatory laminations; tops are bioturbated; beds from 1/4 to 1/2 m thick; tops thoroughly bioturbated. Brown mudstones average 1/2 m thick and are thoroughly bioturbated. Sandstone is quartz rich, with 20% feldspar and 5% mica, subrounded to subangular grains. Contact gradational over two meters with unit above.

74-95m: Fine-grained sandstone with equal amounts of small scale and large scale cross-bedding and planar laminae. Thin brown silty mudstone layers separate some of the sandstone layers near base of interval. Sandstone laminae arranged mostly in wedge to lenticular sets less than one meter thick. Laminae within sets locally disrupted by mottling. Possibly bioturbation; some tabular structures (burrows?). Most sandstone fine-grained, some medium grained, moderately sorted, sand similar in composition to that below. Contact with unit above gradational over 1 m.

95-99m: Parallel laminated, moderately well-sorted, medium-grained, buff colored sandstone. Parallel laminae arranges in wedge sets, many laminae dip about 3 degrees from bedding (paleohorizontal), mostly in one direction. Some laminae disrupted by burrows. Isolated robust-shelled clams, separated valves lie convex-up in sandstone. Sharp contact with unit above.

99-121m: Complexly cross-bedded, very well-sorted, medium-grained sandstone. Cross beds mostly troughs, arranged in lenticular sets averaging 1m thick and 4-5m wide. Some cross beds arranged in wedge sets of tangential cross laminae. Most internal laminae are thinly laminated and defined by very slight grain-size differences, locally planar laminae are indistinctly inversely graded. Other laminae contorted and internally structureless. One bedding plane contains poorly preserved, "star-crested", very low amplitude ripple marks.

Field notes #2

Date 30 October 1982. Location: Roadcut on Highway 10, 2.3 miles east of Weaverville, CO. Section begins at lowermost limestone on the west end of roadcut. Total thickness of upper Paleozoic and Mesozoic section approx. 510m; top and bottom not exposed.

0-30m: Pennsylvanian Weaverville Quartzite. Gray to buff, very well indurated, complexly cross bedded to structureless. Where visible, grains are well sorted, well-rounded and medium grained sand. Cement is quartz as are 99% (?) of grains. Locally, sets of cross-bedded quartzite are wedge shaped to tabular, and average about 0.5m thick. Cross beds are tangential and trough, where visible. Contact gradational over several meters.

30-110m: Pennsylvanian Chester Fm. Marine, sandy limestone. Blue to blue-gray. Fairly resistant (but less than Weaverville Qtz.), typically in thin tabular to lenticular beds 1-10cm thick. Sand forms 10-20% of unit, decreasing in abundance upwards. Limestone is fossiliferous and oolitic. Fossils include disarticulated bivalves and gastropods. Limestone and sandstone layers both extensively rippled and some cross bedded. One prominent oolitic horizon at 78-81m contains large-scale trough cross bedding. Contact with overlying unit disconformable, a few clasts of limestone lie at base of overlying chert.

110-232m: Permian Smithton Chert. Homogeneous, thinly-edged, gray-brown chert. Beds typically a few cm's thick, separated by thin fissile black shale partings. Unit is less resistant than those below, probably due to thin bedding. Small white spots visible on some chert may be radiolarians. Angular unconformity between this and above mudstone, about 10 degrees.

232-288m: Triassic Aurora Mudstone. Red sandy mudstone with local lenticular (channel) sandstone units. Mudstone typically structureless, in beds 0.5-4m thick. Some mudstone contains thin white calcareously-cemented horizons that give the outcrop a striped appearance. Cement clearly diagenetic, as it cuts across locally preserved bedding structures. Channel sandstones are lenticular and range up to 1.5m thick. Pebbles and mudchips lie at base of some sandstones. Beds are cross bedded, with scale of cross bedding decreasing upwards in any given lens. Sand is quartz rich but contains abundant chert and other sedimentary rock fragments, mostly subangular and moderately sorted. Sharp contact with unit above, possibly disconformable.

288-344m: Jurassic Samson Limestone. Brown to gray-brown, silty marine limestone. Beds average 0.3m thick and alternate between calcareously cemented, rippled to plane-bedded siltstone to silty bioclastic limestone. Abraded belemnites lie within limestones locally. Bioclastic limestone is poorly to well sorted, and contains varying proportions of micritic matrix and sparry cement. Limestone contains small scale, cross bedding, parallel lamination and abundant mottling (bioturbation). Contact with unit above gradational over 3 meters.

344-361m: Jurassic Cleveland Fm. Interbedded quartz-rich, fine-grained sandstone and siltstone. Sandstone predominant (80%), and occurs in beds 0.5-1.0m thick. Siltstone forms thin structureless bioturbated zones between thicker sands. Sandstone is typically parallel laminated to low-angle cross laminated and occurs in wedge to tabular beds. One or two very thin zones of ripple cross-bedding lie within the otherwise plane-bedded sandstone. Sandstone is moderately to well sorted, and contains chert in addition to quartz. Forms ledgy slope above the well exposed Cleveland Formation. Sharp disconformity with above unit.

361-510m: Cretaceous Hamilton Shale. Very poorly exposed slopes of black shale. Very fissile, one ammonite collected. Thin interlayers of graded siltstone (2%). A pretty crummy unit!

Exercise 5.4 Miscellaneous measured sections

Following are descriptions from the Colorado Front Range, the Colorado Plateau and central Kansas. Use these data to draft sections as instructed. These sections are reproduced from *Graphic Problems in Petroleum Geology*, by L. W. LeRoy and J. W. Low, Copyright 1954 by Harper & Row, Publishers, Inc., Pages 39-46. Reprinted by permission of the publisher.

Section No. 1

Generalized Composite Stratigraphic Sequence of the Front Range of Colorado

	Thickness (feet)
Recent	
Alluvial sands and gravels	0–25
——Unconformity——	
Tertiary	
Castle Rock conglomerate	
Massive to poorly bedded conglomerate with lenses of coarse-grained, friable sandstone; boulders up to 1 foot in diameter and moderately rounded.	0–50
——Unconformity——	
Green Mountain conglomerate	
Coarse-grained sandstone and boulder conglomerate; only slightly cemented; grades into upper part of Dawson arkose.	600
——Unconformity——	
Tertiary-Cretaceous	
Denver	
Drab siltstones, fine-grained sands, and sandy mudstones; 30-foot conglomerate at base; Table Mountain basalts in upper fourth; upper part grades laterally into lower part of Dawson arkose.	1100
——Unconformity——	
Cretaceous	
Laramie	
Interbedded fine-grained, firm sandstones; dark gray carbonaceous clays, and siltstones; few lignites in lower part; sand-clay ratio 8:1.	400–600
Fox Hills	
Essentially medium- to fine-grained, light tan to buff sandstone; few olive-brown sandy shales.	50–120
Pierre	
Dark gray arenaceous shale and mudstone; common laminae of fine-grained sand and silt; Hygiene sandstones locally developed in middle part.	8000
Niobrara Group	
Apishapa	
Dark gray foraminiferal, calcareous shale; weathers yellowish-orange to buff.	400
Timpas	
Thin-bedded, light gray foraminiferal limestone with thin beds of dark gray calcareous shale; limestone-shale ratio 20:1.	35–50
——Unconformity——	
Benton Group	
Carlile	
Light tan to gray medium-grained, friable, slightly calcareous sandstone; locally developed; petroliferous odor at some localities.	0–25

Exercise 5.4 Miscellaneous measured sections

Following are descriptions from the Colorado Front Range, the Colorado Plateau and central Kansas. Use these data to draft sections as instructed. These sections are reproduced from *Graphic Problems in Petroleum Geology*, by L. W. LeRoy and J. W. Low, Copyright 1954 by Harper & Row, Publishers, Inc., Pages 39-46. Reprinted by permission of the publisher.

Section No. 1

Generalized Composite Stratigraphic Sequence of the Front Range of Colorado

	Thickness (feet)
Recent	
Alluvial sands and gravels	0–25
—Unconformity—	
Tertiary	
Castle Rock conglomerate	
Massive to poorly bedded conglomerate with lenses of coarse-grained, friable sandstone; boulders up to 1 foot in diameter and moderately rounded.	0–50
—Unconformity—	
Green Mountain conglomerate	
Coarse-grained sandstone and boulder conglomerate; only slightly cemented; grades into upper part of Dawson arkose.	600
—Unconformity—	
Tertiary-Cretaceous	
Denver	
Drab siltstones, fine-grained sands, and sandy mudstones; 30-foot conglomerate at base; Table Mountain basalts in upper fourth; upper part grades laterally into lower part of Dawson arkose.	1100
—Unconformity—	
Cretaceous	
Laramie	
Interbedded fine-grained, firm sandstones; dark gray carbonaceous clays, and siltstones; few lignites in lower part; sand-clay ratio 8:1.	400–600
Fox Hills	
Essentially medium- to fine-grained, light tan to buff sandstone; few olive-brown sandy shales.	50–120
Pierre	
Dark gray arenaceous shale and mudstone; common laminae of fine-grained sand and silt; Hygiene sandstones locally developed in middle part.	8000
Niobrara Group	
Apishapa	
Dark gray foraminiferal, calcareous shale; weathers yellowish-orange to buff.	400
Timpas	
Thin-bedded, light gray foraminiferal limestone with thin beds of dark gray calcareous shale; limestone-shale ratio 20:1.	35–50
—Unconformity—	
Benton Group	
Carlile	
Light tan to gray medium-grained, friable, slightly calcareous sandstone; locally developed; petroliferous odor at some localities.	0–25

	Thickness (feet)
Dark gray slightly silty, calcareous shale; occasional thin purple limestone layers in lower part; large concretions locally in middle part.	160–200
Greenhorn	
Alternating fine-crystalline, light bluish-gray argillaceous limestone and dark gray foraminiferal shale; limestone-shale ratio 1:5.	40–60
Graneros	
Dark gray thin-bedded, slightly silty shale; thin bentonite streaks.	275–320
Dakota Group	
Gray medium-grained, friable sandstone.	50
Dark gray fissile, carbonaceous shale.	100
Coarse-grained to conglomeratic, gray friable sandstone.	50
——Unconformity——	
Jurassic	
Morrison	
Light gray shale, marlstone, sandstone, and minor vari-colored mudstone; marlstone and shale predominate; many sandstones at base; sandstones rarely exceed 10 per cent of formation.	275–300
Ralston	
Light gray mudstone, fine-grained, yellowish sandstone and siltstone; local gypsum phases.	0–80
Entrada	
Red to salmon colored, medium-grained, friable sandstone.	30
——Unconformity (?)——	
Triassic	
Jelm	
Red medium-grained, cross-bedded sandstone.	30–50
——Unconformity (?)——	
Lykins	
Strain member	
Red thin-bedded siltstone.	300
Permian	
Glennon member	
Gray to pink laminated, silty limestone; top is Triassic-Permian boundary.	10
Bergen member	
Thin-bedded red siltstone.	60
Falcon member	
Pink to gray laminated, silty limestone.	4
Harriman member	
Red thin-bedded siltstone; few thin white limestone layers near base; local gypsum at base.	90
Lyons	
Gray to pinkish-red medium- to coarse-grained sandstone; conspicuously cross-bedded; ridge former	115–420
Satanka (Lower)	
Red siltstone and fine-grained sandstone; grades into basal part of Lyons.	0–150

	Thickness (feet)
Permian-Pennsylvanian	
Ingleside	
Interbedded, fine-grained, red friable sandstones, sandy shales, and gray to pink dense- to medium-crystalline limestones; limestones locally up to 15 per cent of formation; sandstones locally cross-bedded.	0–450
Pennsylvanian	
Fountain	
Thick-bedded, red conglomeratic arkosic, poorly sorted sandstones and red siltstones; few thin, dense pink limestone lenses in upper and basal phases; some cross-bedding; moderate topographic relief.	750–1470
Glen Eyrie	
Thin-bedded red and green sandstones, siltstones, and mudstones; few thin, fine-crystalline, sandy limestones containing a few fossils.	200
——Unconformity——	
Mississippian	
Beulah	
Fine-crystalline, sandy, micro-oölitic, gray medium-bedded limestone; some chert.	50
Hardscrabble	
Hard, dense, gray limestone; breccia at base; ridge former; some chert.	125
——Unconformity——	
Williams Canyon	
Thin-bedded, sandy, gray to pink, mottled, flaggy limestone.	0–50
——Unconformity——	
Ordovician	
Fremont	
Massive-bedded, buff medium-crystalline, vuggy limestone and dolomitic limestone; highly jointed; few scattered chert nodules; cliff former.	0–270
——Unconformity——	
Harding	
Fine-grained, well-sorted, white friable sandstone; few interbeds of sandy, vari-colored claystones and mudstones in middle part; locally conglomeratic at base; generally a slope former; fossiliferous.	0–150
——Unconformity——	
Manitou	
Red to brownish-red fine-crystalline, dolomitic limestone and dolomite; thin to medium-bedded; chert nodules in lower part; locally arenaceous in basal part; escarpment former; few fossils.	0–190
Cambrian	
Ute Pass	
Red coarse-crystalline, sandy, glauconitic dolomite and dolomitic sandstone.	0–14
Sawatch	
Coarse-grained, friable, conglomeratic sandstone; gray to white; locally cross-bedded; slightly calcareous and glauconitic in extreme upper part; conglomerates best developed in basal part.	0–90
——Unconformity——	
Pre-Cambrian	
Gneiss, schist, and granite.	

Section No. 2

Generalized Colorado Plateau Section[1]

	Thickness (feet)
Tertiary	
Wasatch	
Limestones, shales, and sandstones; basal conglomerate.	400–1500
——Unconformity——	
Cretaceous	
Mesaverde	
Shales and sandy shales, gray, and massive thick sandstones; local coal beds; subdivided locally into many formations.	300–3000
——Unconformity——	
Jurassic	
Undifferentiated Jurassic (?)	
Pink gypsiferous sandstones, red and gray shales, and gray limestones; possibly includes Morrison equivalent.	250
Carmel	
Alternating limestones, calcareous red and gray shales and minor sandstones.	100–250
Navajo	
Cross-bedded, medium-grained, friable sandstones.	500+
Kayenta	
Calcareous red and gray shales and thin gray limestones.	300+
Wingate	
Coarse- to medium-grained, gray to pink sandstone.	500+
——Unconformity——	
Triassic	
Chinle	
Brilliantly colored red, green, purple, white shales, sandstones and mudstones; numerous agatized wood fragments; occasional thin limestones, bedded cherts, and conglomerates.	400–1000
Shinarump	
Poorly sorted, massive-bedded, pebble to cobble conglomerate and coarse-grained sandstones; cementation variable; cliff-forming locally; moderately cross-bedded.	25–100
Moenkopi	
Interbedded, red shales, conglomerates, thin limestones, and massive sandstones; selenitic phases locally.	400–1800
——Unconformity——	
Permian	
Kaibab	
Yellow to white pure limestone and sandy limestone; chert nodules throughout; very fossiliferous; forms Grand Canyon rim surface on south and north sides; many local facies.	200–1000

[1] Modified after H. E. Gregory, *International Geological Congress Guidebook 18*, 1933.

Section No. 3

Detailed "Permian" Stratigraphy of Kansas[1]

	Thickness (feet)
Cretaceous	
———Unconformity———	
Permian	
Cimarron Series	
Greer	
Big Basin sandstone: Massive, red and/or gray.	12
Shale: Maroon.	20
Woodward	
Day Creek: Hard, white dolomite.	4
Whitehorse: Fine-grained, light red sandstone and sandy shale.	200
Dog Creek: Dull red clay-shale with thin dolomitic limestone beds.	30
Cave Creek	
Shimer: Massive gypsum.	5
Jenkins: Red shale.	5
Medicine Lodge: White to gray massive gypsum.	20
Enid	
Flowerpot shale: Variegated, gypsiferous.	175
Cedar Hills sandstone: Hard, bright red, massive; interbeds of red sandy shale.	250
Harper sandstone: Reddish-brown sandstone and sandy shale.	700
———Unconformity———	
Big Blue Series—Sumner Group	
Wellington	
Shale and Geuda salt: Light gray and red shale and salt beds.	500±
Carlton limestone: Light gray, flaggy; with pelecypods, insects, and plant remains near base.	18
Buckeye shale: Essentially gray; some thin red shale and gypsum.	235
Donegal	
Strickler limestone: White, flaggy; unfossiliferous.	2
Newbern shale: Gray, calcareous.	11
Hollenberg limestone: Brown, flaggy; foraminifera common.	7
Pearl	
Gray, green, and red clay-shale.	27
Nolans	
Herington limestone: White to buff, massive, flaggy, impure, dolomitic; fossiliferous.	8
Paddock shale: Gray to olive drab, clayey.	14
Krider limestone: White to gray limestone and calcareous shale; fossiliferous.	6
Odell	
Olive drab, gray, and maroon shale.	20

[1] Slightly modified from Raymond C. Moore.

	Thickness (feet)
Big Blue Series—Chase Group	
Winfield	
Luta limestone: Light bluish-gray, flaggy to platy, earthy.	7
Cresswell limestone: Gray, massive to thin-bedded, cherty; echinoid remains common.	9
Grant shale: Light gray, clayey; thin fossiliferous limestones near top.	12
Stovall limestone: Dark gray, granular; fossiliferous; commonly cherty.	2
Gage	
Gray, green, and red clay-shale; fossil zone near top.	40
Towanda	
Drab to green flaggy limestone; gastropods common.	11
Holmesville	
Light gray and red clay-shale.	30
Barneston	
Fort Riley limestone: White to buff, massive; fossiliferous.	10
Oketo shale: Light gray, calcareous.	5
Florence limestone: Bluish-gray with abundant nodules and beds of dense chert.	25
Blue Rapids	
Green and red clay-shale; limestone near middle.	28
Kinney	
Gray limestone and shale.	11
Wymore	
Olive green, gray, and red clay-shale.	29
Wreford	
Schroyer limestone: Gray, cherty.	9
Havensville shale: Olive and gray, calcareous.	20
Threemile limestone: Gray to bluish-gray, massive, chert-bearing.	11
Big Blue Series—Council Grove Group	
Speiser	
Green, gray, and red clay-shale with local thin limy and sandy beds.	17
Bigelow	
Funston limestone: Bluish-gray to buff, massive; gastropods common.	5
Blue Rapids shale: Gray, green, and red clay and sandy shale.	28
Crouse limestone: Gray massive limestone and calcareous shale; fossiliferous.	13
Easly Creek	
Gray, green, and red shale and gypsum.	15
Bader	
Middleburg limestone: Dark gray massive, impure; numerous gastropods.	5
Hooser shale: Green, gray, and red calcareous shale.	8
Eiss limestone: Bluish-gray limestone and shale; fossiliferous.	7
Stearns	
Green and red shale; locally with platy beds.	18
Beattie	
Morrill limestone: Dark gray; fossiliferous.	2

	Thickness (feet)
Florena shale: Light gray, calcareous; brachiopods and bryozoans abundant.	9
Cottonwood limestone: Light gray to buff, massive; local chert nodules; abundant fusulinids.	6
Eskridge	
Light green and red clay-shale; some thin, impure limestone beds.	33
Grenola	
Neva limestone: Light gray to white, massive to flaggy.	18
Salem Point shale: Dark gray, hard, calcareous.	7
Burr limestone: Gray to buff, impure; fossiliferous.	8
Roca	
Green, gray, and red clay-shale.	21
Red Eagle	
Howe limestone: Buff, impure; nonfossiliferous.	1
Bennett shale: Dark gray to black; fossiliferous.	8
Glenrock limestone: Gray, massive; abundant fusulinids.	5
Johnson	
Gray, green, and red shale; unfossiliferous.	15
Foraker	
Long Creek limestone: Buff, massive to thin-bedded; few fossils.	5
Hughes Creek shale: Light gray calcareous shale and thin limestone with abundant fusulinids, brachiopods, and bryozoans.	39
Americus limestone: Gray limestone and black clay-shale; fusulinids common.	5
Big Blue Series—Admire Group	
Hamlin	
Oaks shale: Gray, green, and red.	21
Houchen Creek limestone: Gray, algal.	1
Stine shale: Green, gray, and red.	23
Five Point	
Gray massive to flaggy, fossiliferous limestone.	4
West Branch	
Gray, green and red shale; unfossiliferous.	29
Falls City	
Gray to buff, massive limestone and shale; upper part coquinoid and porous.	6
Hawxby	
Dark gray shale with thin limestones; pelecypods abundant.	13
Aspinwall	
Light gray and buff, fine-crystalline limestone; locally fossiliferous.	4
Towle	
Shale member: Green and red, clayey and sandy.	16
Indian Cave sandstone: Light brown, massive, cross-bedded; conglomerate near base locally.	0–120

Unconformity

Pennsylvanian

Exercise 5.5 - Correlation of measured sections

Even though you learned to correlate sections in Chapter 2, several additional correlation exercises are included here so that you can gain experience both in drafting and correlating measured sections. Please refer back to Chapter 2 if you need help with the principles of stratigraphic correlation.

Exercise 5.5.1

Often drafted sections are correlated as in the exercises of Chapter 2. Columns to be correlated are drafted much as the previous graphic section, except that descriptions, age columns and written information is deleted; all information is represented by symbols. Listed below are three sections with lithologies and thicknesses. The sections are 100 miles apart. Complete the following:

1. Construct 3 columns using a vertical scale of either 1" = 200' or 1" = 100'. Draft the sections on quality paper.

2. Do not include descriptions or thicknesses. Instead include a key or legend with a vertical scale and an explanation of the symbols used.

3. Use with a straight right margin or one that illustrates grain size or weathering profile.

4. Correlate the units on the basis of lithologies

5. Divide the units into formations, members and facies.

6. Make any time correlations that you think are appropriate.

7. Write a paragraph describing the reasons for your correlations and the possible processes and/or environments of deposition.

Section 1. West
TOP
120 feet Thinly bedded fossiliferous biomicrite

200 feet Laminated fissile red silty mudstone. Grades into the overlying unit over a 10 foot interval. Includes a 6 inch bentonite layer 60 feet from the base of the unit.

340 feet Trough cross-bed and ripple cross-laminated fine to medium grained, well sorted quartz sandstone. Sharp contact with overlying unit.

250 feet Laminated fissile black mudstone. Sharp contact with overlying unit.

200 feet Massive limestone, sharp contact with above unit.

320 feet Massive to trough cross-bedded and graded units of medium to coarse-grained quartzo-feldspathic sandstone. Includes a 50 foot basal cobble and pebbly conglomerate and pebbly sandstone that fines upward into the main part of the unit. The top of the units grades into the overlying unit over a 20 - 50 foot interval.

BASE

Section 2 - Central

TOP
250 feet Thinly bedded fossiliferous biomicrite

100 feet Laminated fissile silty mudstone with graptolites. Grades over 10 feet into the above unit.

300 feet Cross bedded, plane bedded and ripple cross-laminated fine-grained quartz sandstone. Sharp contact with overlying unit. Includes a 2 foot thick ash bed 100 feet from the base.

UNCONFORMITY

BASE

Section 3 - East

TOP
400 feet Medium bedded fossiliferous biomicrite

75 feet Laminated black shaley silty mudstone with bedded chert nodules. No fossils. Grades into overlying unit over a 15-20 foot interval.

200 feet Coarse-grained pebbly quartz sandstone and pebble conglomerate. Sharp contact with above unit.

150 feet Laminated fissile black mudstone shale. Sharp contact with above unit.

100 feet Massive limestone. Sharp contact with above.

200 feet Massive to trough cross-bedded and graded units of medium to coarse-grained quartzo-feldspathic sandstone. Includes a 25 foot basal cobble and pebbly conglomerate and pebbly sandstone that fines upward into the main part of the unit. The top of the units grades into the overlying unit over a 20 - 50 foot interval. Includes a 2 foot thick bentonite ash bed 180 feet above the base of the unit.

BASE

Exercise 5.5.2

Draft and correlate the following four measured sections. Use any horizontal and vertical scale that you choose. After you have drafted and correlated the sections subdivide the area into formal lithostratigraphic units. All thickness measurements given in feet. Measurements for the "Oil Well Section" given as well depth. Write a paragraph describing the reasons for your correlations and your interpretations of the depositional system.

WEST ROADCUT SECTION

490 - 600	thin bedded micritic limestone
360 - 490	thinly lam sh, slty in places
310 - 360	med bedded sucrosic dolomite
270 - 310	lam gray shale
240 - 270	med bedded med gr qtz-fs ss, calc at base
200 - 240	thin bedded biomicrite - grades into overlying unit
85 - 200	thin lam fissile bl sh
0 - 85	thn bedded med gr ss at base crsns up to thick bed crs ss

STREAM VALLEY SECTION - 70 miles east of West Roadcut Section

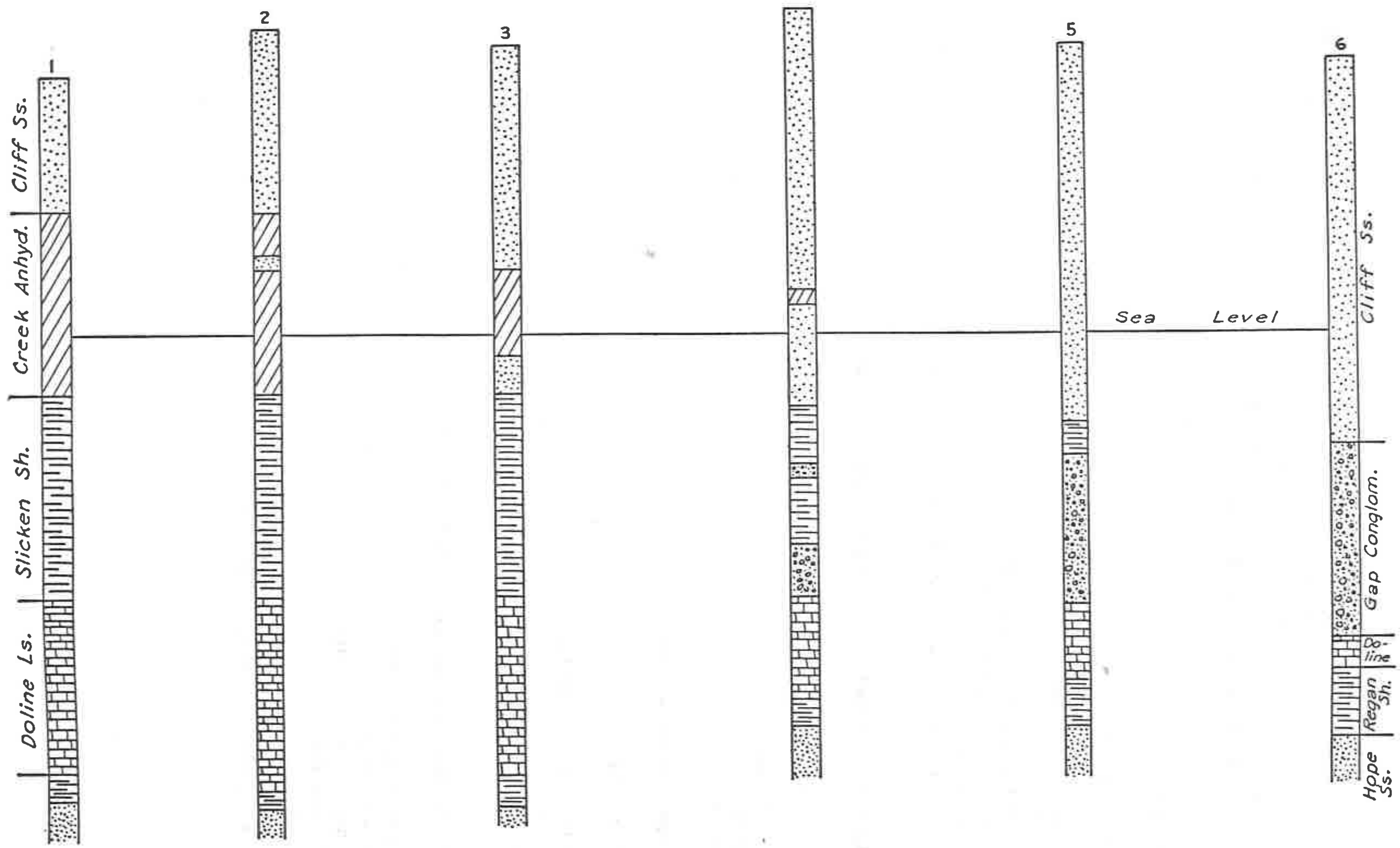
535 - 650	thin bedded micritic ls
505 - 535	bl sh
495 - 505	thin bedded micritic ls
345 - 495	gy silty lam sh
315 - 345	sucrosic dolostone
260 - 315	bl sh
250 - 260	th bedded ripple x-lam med gr ss
215 - 250	black shale
210 - 215	thin lam biomicrite
120 - 210	bl sh
110 - 120	crs gr qtz siltstone and f gr silty ss
90 - 110	bl sh
0 - 90	med bedded qtz ss, crs gr at base, med gr at top

EAST CLIFF SECTION - 50 miles east of Stream Valley Section

560 - 570	thin bedded micritic limestone
400 - 560	gy-green sh with bl blebs
370 - 400	coral boundstone and biosparite
150 - 370	gy-gr and bl thin lam sh
100 - 150	qtz silty wacke
60 - 100	trough cross-bedded qtz ss
0 - 60	crs cobble congl at base fines up to pbly x-bed ss

OIL WELL SECTION

0 - 75	thin bedded biomicrite
75 - 475	bl sh, thin lam, slty in places
475 - 535	silty wacke
535 - 550	trough cross-bedded qtz-fs ss
550 - 635	boulder to cobble congl



Exercise 5.5.3.

Correlate the following six stratigraphic sections taken from boreholes. Write a paragraph discussing processes of deposition the processes responsible for the intertonguing of various deposits. Reproduced from *Graphic Problems in Petroleum Geology*, by L. W. LeRoy and J. W. Low, Copyright 1954 by Harper & Row, Publishers, Inc., Fig. 17, p. 89. Reprinted by permission of the publisher.

Exercise 5.6 Construct a Jacob's staff and measure a section

Every stratigrapher who plans to measure a section in the field should consider making a Jacob's staff. This is a simple inexpensive project and will produce a good staff that will last for many years. The procedure involves obtaining a suitable stick of about 3cm x 3cm or 2-3cm in diameter (a 1"X2" will do nicely). The exact size does not matter as long as the staff is stiff and not too bulky, old broomsticks, finish lumber, or plastic pipe work well. Next cut the stick to a length of 1.5 meters. Next, you need to paint alternating 10cm strips along the length of the stick. Traditionally red and white or black and white stripes are used. The easiest way is to paint the entire staff white and then with masking tape mark off and apply the colored paint. For a quick job you can even mark 10cm increments on an unpainted stick with a marking pen or you could even follow Jacob's example and peel strips of bark from a stick of green poplar, hazel or chestnut. However, unless you need to induce cows to give birth to speckeled calves, you should use bright paint as these marks will not show up well from a distance or in a photograph.

After making a suitable Jacob's staff go on a trip to an outcrop of layered rocks and measure a section using the information in this chapter, the rock classifications, cheklists, log sheets, sample descriptions and field note and measure a section on your own. Return to the laboratory and draft the information as a graphic column.