Geology and Geophysics 303
Structural Geology
Course Notes

Steve Martel

Department of Geology and Geophysics

University of Hawaii

http://www.soest.hawaii.edu/martel/Stevem.html

Index

INTRODUCTION AND COURSE PHILOSOPHY

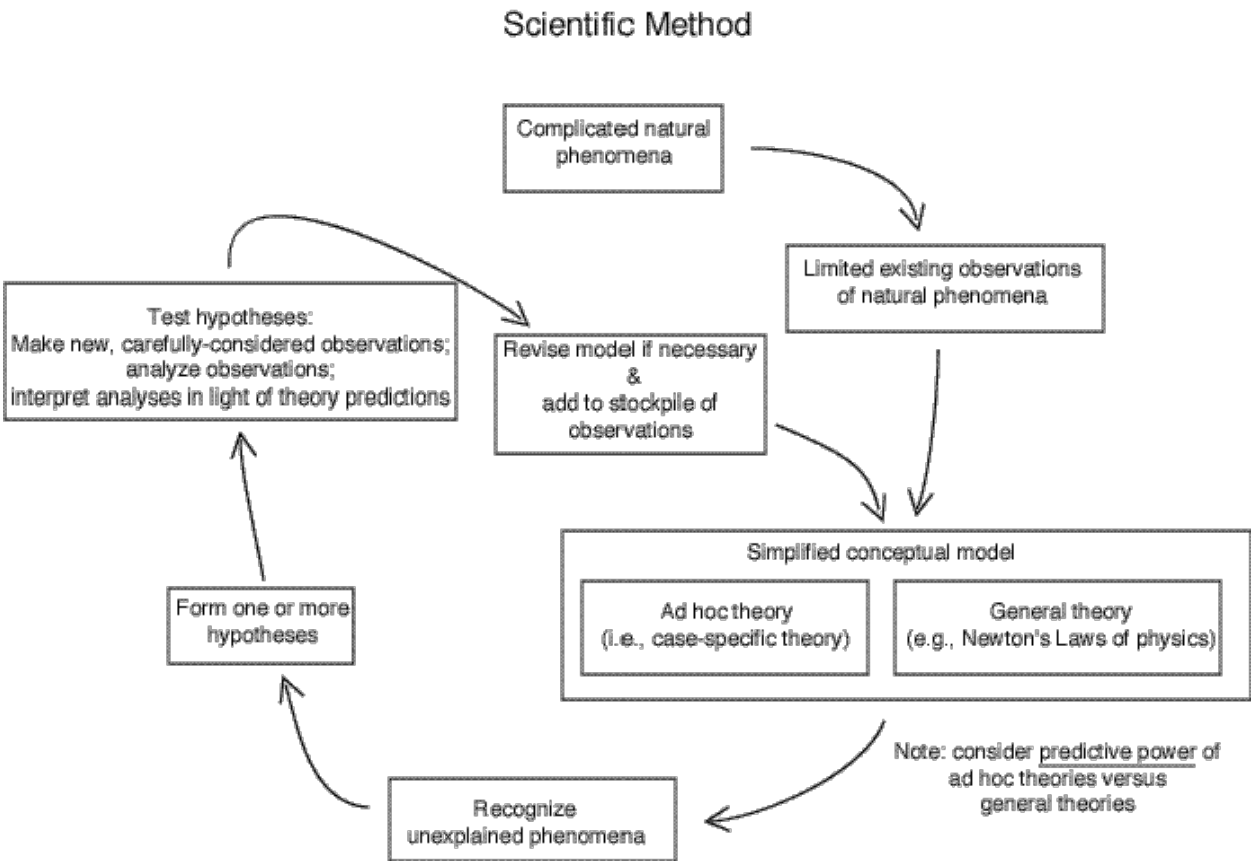
I Main Topics
- A What is science?
- B Course philosophy

II What is science?
- A Possession of knowledge as distinguished from ignorance or misunderstanding;
- B Knowledge attained through study and practice
- C Knowledge covering general truths or the operation of general laws especially as obtained and tested through the scientific method
- D Scientific Method
  Principles and procedures for the *systematic* pursuit of knowledge involving the *recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.*

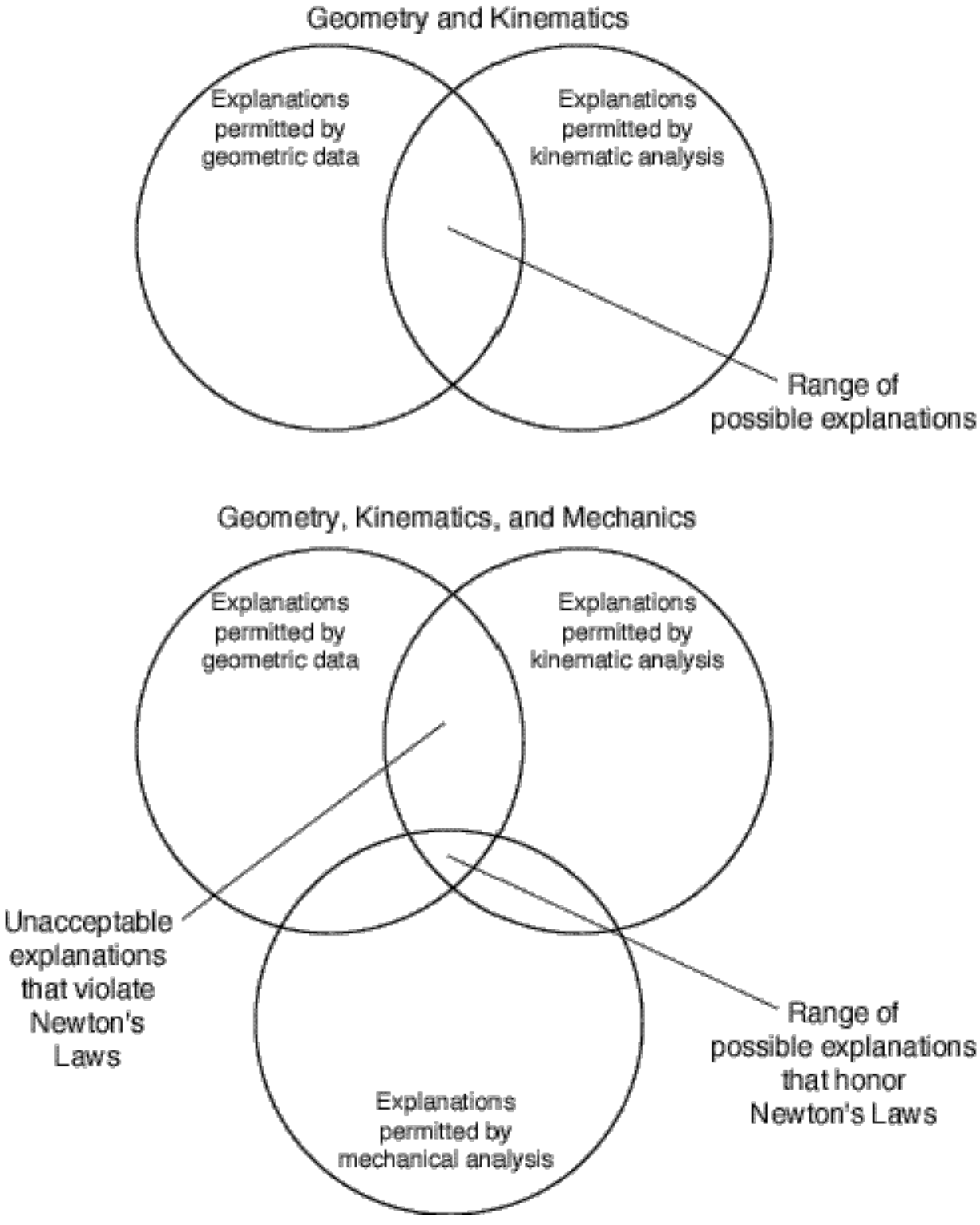
II Course philosophy
- A Geology can be treated as a scientific discipline
- B Course emphases
  1. Concepts (not vocabulary)
  2. Critical thinking (not "cookbooks")
  3. Fundamentals (not fashion)
  4. Quantitative predictions (Where? When? How big?)
- C Topics of this course

Topic	Definition	Application to structural geology
Descriptive geometry	The representation of the spatial relationships of points lines and planes by means of projections	Used to describe the geometry of deformed or undeformed bodies Focus of first half of class
Kinematics	The study of the position of bodies through time without regard to the causative forces	Used to describe how a body changes shape and/or position through time
Mechanics	The study of forces and their effects (e.g., how bodies deform in response to forces)	Used to understand and predict how bodies deform

Fig. 1.1


Scientific Method
Complicated natural phenomena
Limited existing observations of natural phenomena
Revise model if necessary & add to stockpile of observations
Test hypotheses: Make new, carefully-considered observations; analyze observations; interpret analyses in light of theory predictions
Simplified conceptual model
Ad hoc theory (i.e., case-specific theory)
General theory (e.g., Newton's Laws of physics)
Form one or more hypotheses
Note: consider predictive power of ad hoc theories versus general theories
Recognize unexplained phenomena

Why Use Geometry, Kinematics, and Mechanics? Fig. 1.2



Conversion Factors

Prefixes

μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}

Key constants

g	9.8 m/sec/sec

Quantities

Mass	1 kg	1000 grams	2.205 lbs	
	1 ton	2000 lbs		
	1 lb	0.4536 kg		
Note: tons and pounds are really weights (i.e., forces), not masses				
Length	1 inch	2.54 cm		
	1 meter	39.37 inches	3.281 feet	
	1 foot	0.3049 m		
	1 km	0.622 miles		
	1 mile	1609 meters	1.609 km	
Time	1 year	3.1557×10^{7} sec		
	1 hour	3600 sec		
Density	1 g/cm^3	1000 kg/m^3		
Force	1 kg weight	9.807 N		
F = ma	1 ton	2000 lbs		
	1 lb	0.4536 kg		
	1 kg	2.205 lbs		
	1 N	10^{5} dynes		
Pressure	1 Mpa	10^{6} Pa	1 MPa	145.03 psi
(P =F/area)	1 atm	$1.013\ 10^{5}$ Pa	0.1013 MPa	14.7 psi
	1 bar	10^{5} Pa	0.1 Mpa	14.503 psi
	10 bars	10^{6} Pa	1Mpa	145.03 psi
	1 psi	689.5 Pa	689.5×10^{-3} MPa	1 psi
	10 m water	$\approx 10^{5}$ Pa	≈ 0.1 Mpa	≈ 14.7 psi
Energy	1 calorie	4.184 joule		
	1 joule	10^{7} ergs		
Power	1 watt	1 joule/sec		

Note: Power = energy / unit time

"Permeability" (hydraulic conductivity) The hydraulic conductivity (K) depends on the density & dynamic viscosity of the fluid and the intrinsic permeability (K_i) of the medium {$Q = -K\ A\ (dh/dl)$; $K = K_i(\rho g)/\mu$}. K has dimensions of speed; K_i of area. For water at 15.6° C:

If K=1 m/sec, then...	$K_i = 1.161 \times 10^{5}$ Darcies	$K_i = 1.15 \times 10^{-3}$ cm^2
If K_i=1 Darcy, then...	$K = 8.61 \times 10^{-6}$ m/sec	$K_i = 9.87 \times 10^{-9}$ cm^2

Addendum

Middleton, G.V. and P.R. Wilcock "Mechanics in the Earth and Environmental Sciences"

List of known corrections to First Printing
(http://www.science.mcmaster.ca/geo/mwcorrect.htm)

p.49, unnumbered equation above (2.89): delete minus

p.49, lines 2-3 above bottom: delete sentence beginning "The new coordinates..."

p.81, in Equation (3.16) 6 *should be* 24, i.e. $C_D = 24/Re$

p.106, line 23: certain *should be* shear

p.121, line 10: *should read* clockwise: $\tau_{yx}(\delta x)^3$ anticlockwise: $\tau_{xy}(\delta x)^3$ i.e., the gammas should be taus, and the exponent *should be* 3 not 2.

p.207, line 7: in the formula K *should be* (k/g)

p.289, line 1: grad *should be* div.

p.293, line 2 from bottom: RHS of equation $\rho\ c_o^2/\lambda$ i.e., switch the numerator and divisor.

p.294, line 4-5: *should read* between the representative velocity and the speed of sound C, in the substance.

p.405, last line of Equation (12.21): RHS *should be* XY -bZ