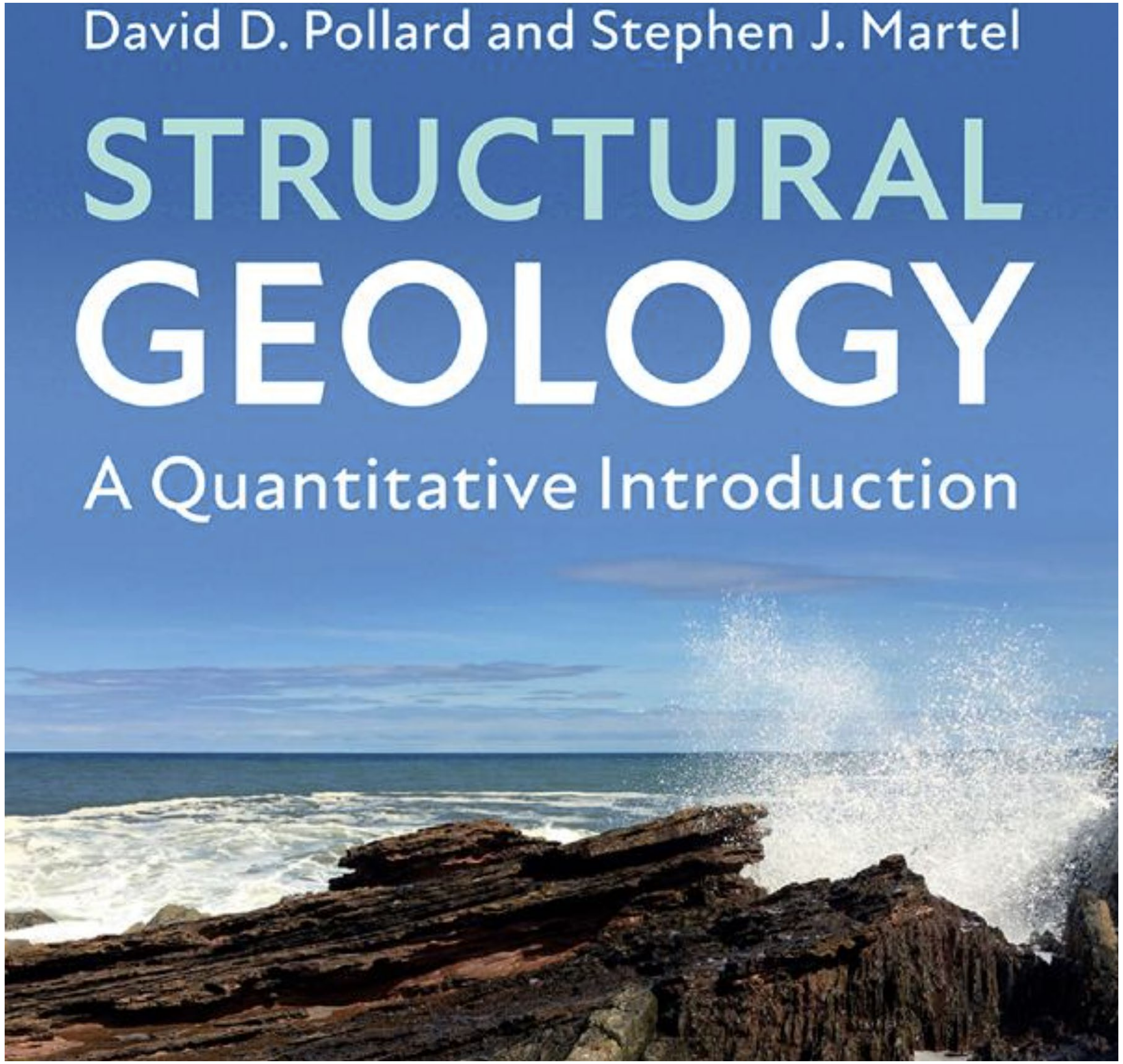
Advanced Structural Geology, Fall 2022



Preface and Chapter 1

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Announcements

- No class meeting next week Sept 9 but there will be tasks to complete at that time.
- Working on Field Trip dates

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Structural Geology

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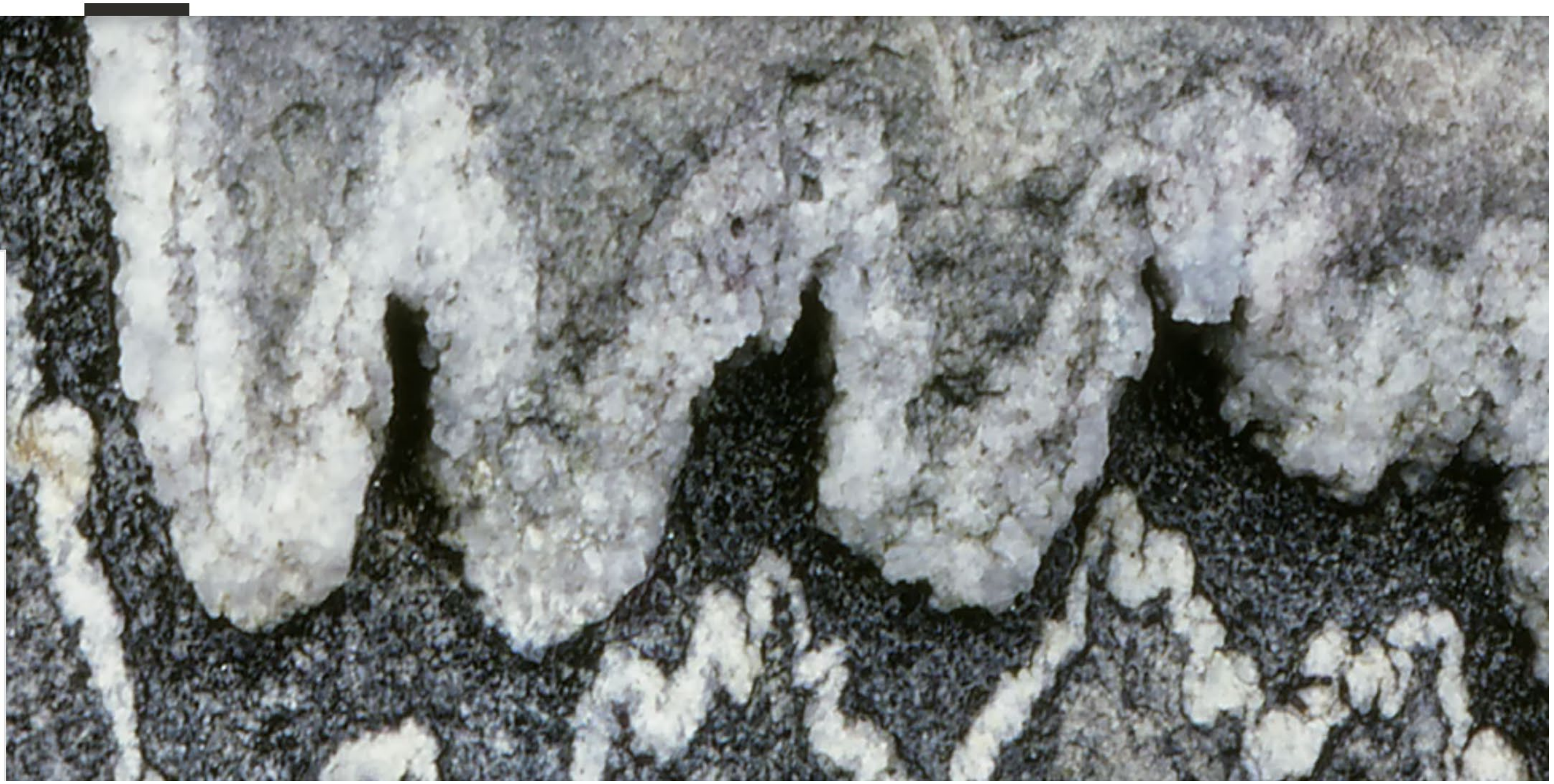

Welcome to David Pollard's Structural Geology website

Scroll down to find recent Announcements and topics In the Spotlight.

The main menu link "QSG Textbook" leads to materials about the undergraduate textbook *Structural Geology: A Quantitative Introduction* by

Prof David Pollard Retirement 2015

Martel

Pollard

-What is different about the approach of this book for Structural Geology?

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This textbook also is appropriate for geology students whose first course in structural geology was primarily descriptive and qualitative. In addition, the quantitative approach used here has proven to be accessible and useful for students from other disciplines, such as geophysics, petroleum engineering, and civil engineering, who are likely to be working with structural geologists in their professional careers. Both authors have welcomed students from other disciplines in their structural geology courses, and both have found that these students enrich the experience for the geology students.

Although this textbook is a first course in structural geology, it takes a decidedly different approach to the subject matter than other "first course" textbooks, which focus on descriptions of structures and *qualitative* explanations for their formation. Our goal is to provide a balance between description and analysis of structures, so we offer *quantitative* explanations for their formation, based on the physics of deformation. Despite this difference in approach, the topics we cover are similar to those in other "first course" textbooks. For example, chapters are devoted to the basic categories of geologic structures including fractures, faults, folds, fabrics, and intrusions. However, the shift to a quantitative treatment of the formation of structures necessarily relies on more equations to build the student's knowledge base. We find that carefully labeled diagrams complement the equations substantially, so we include many diagrams in the textbook.

-What is a "canonical problem"?

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Canonical models in structural geology are those that reduce the physical processes generating geologic structures to the simplest form possible, without too much loss of generality. From the etymology of canon (Greek, *kanōn*) we understand that this word means rod, rule, or *measuring stick*. In other words, we expect these problems to be used as measuring sticks from which we draw some understanding of the more complicated geologic structure. Because geologic structures develop when rocks physically deform, we anticipate that well-defined and idealized models from that part of physics called mechanics will serve as the measuring sticks.

In parlance drawn from another branch of geology, we intend these canonical problems to stand like the *type locality* of a named sedimentary unit. The type locality serves as the standard of reference by which that unit is identified at other localities. For this textbook it is not a locality or physical object, but a well-defined problem of mechanics that serves as a *standard of reference* for the physical process that led to the development of a geologic structure.

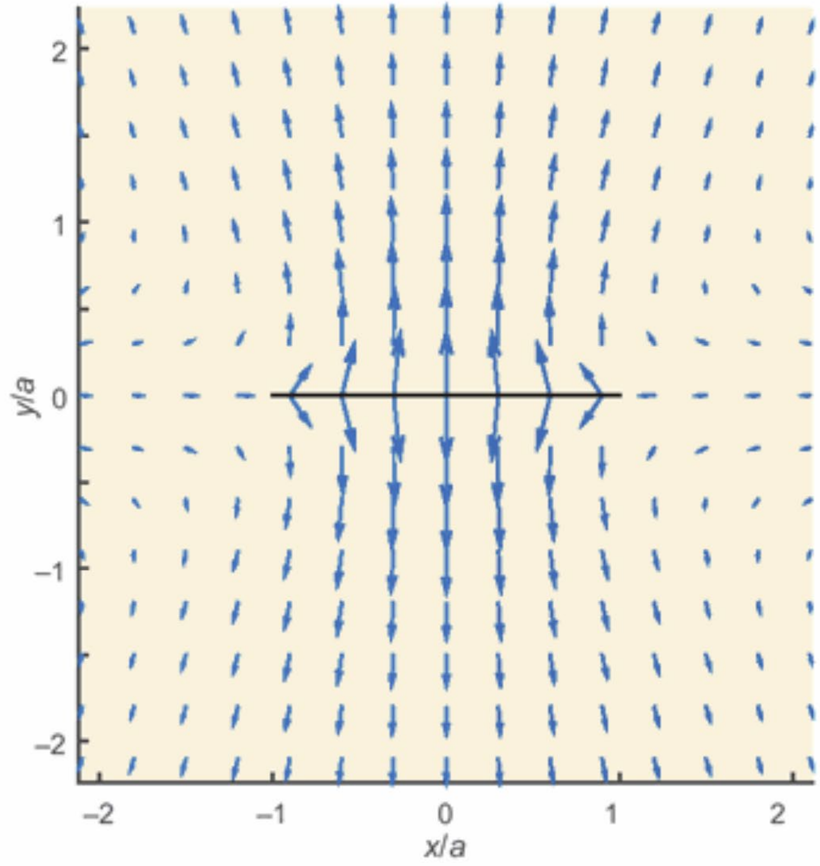

Figure 7.19 Displacement field for the opening fracture in an elastic solid. Using, $\Delta\sigma_I \approx 1$ MPa, and elastic moduli $G = 3{,}000$ MPa and $\nu = 1/4$, the greatest displacement has a value 0.25×10^{-3} m. Displacement magnitude is greatly exaggerated, so vectors can be visualized. Calculation based on Pollard and Segall (1987).

-What are the three styles of deformation?

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- Brittle--Discrete failure accommodates deformation; formation of faults and fractures
- Ductile—Distortion without fracture; distributed deformation
- Viscous—Flow (water, magma)

-Which is your favorite of the five classes of geologic structures and why?

-Which is your favorite of the five classes of geologic structures and why?

- Fractures
- Faults
- Folds
- Fabrics
- Intrusions

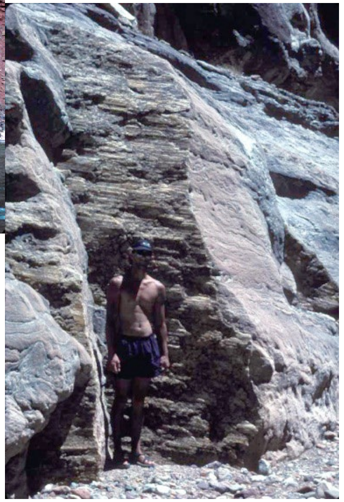
The Fundamental Structures

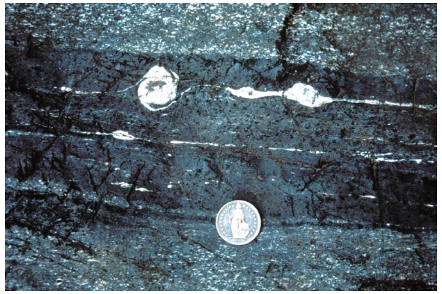
- Contacts: Depositional, unconformities, intrusive, fault, shear zones
- Primary structures: Those that develop during the formation of a rock body
  - In magma/lava before it becomes intrusive/volcanic rock
    - Vesicles, flow banding, etc.
  - In seds before they become sed rox
    - Cross beds, ripple marks, etc.
  - In metamorphic rocks most of these are secondary

Climbing ripple cross stratification

The Fundamental Structures

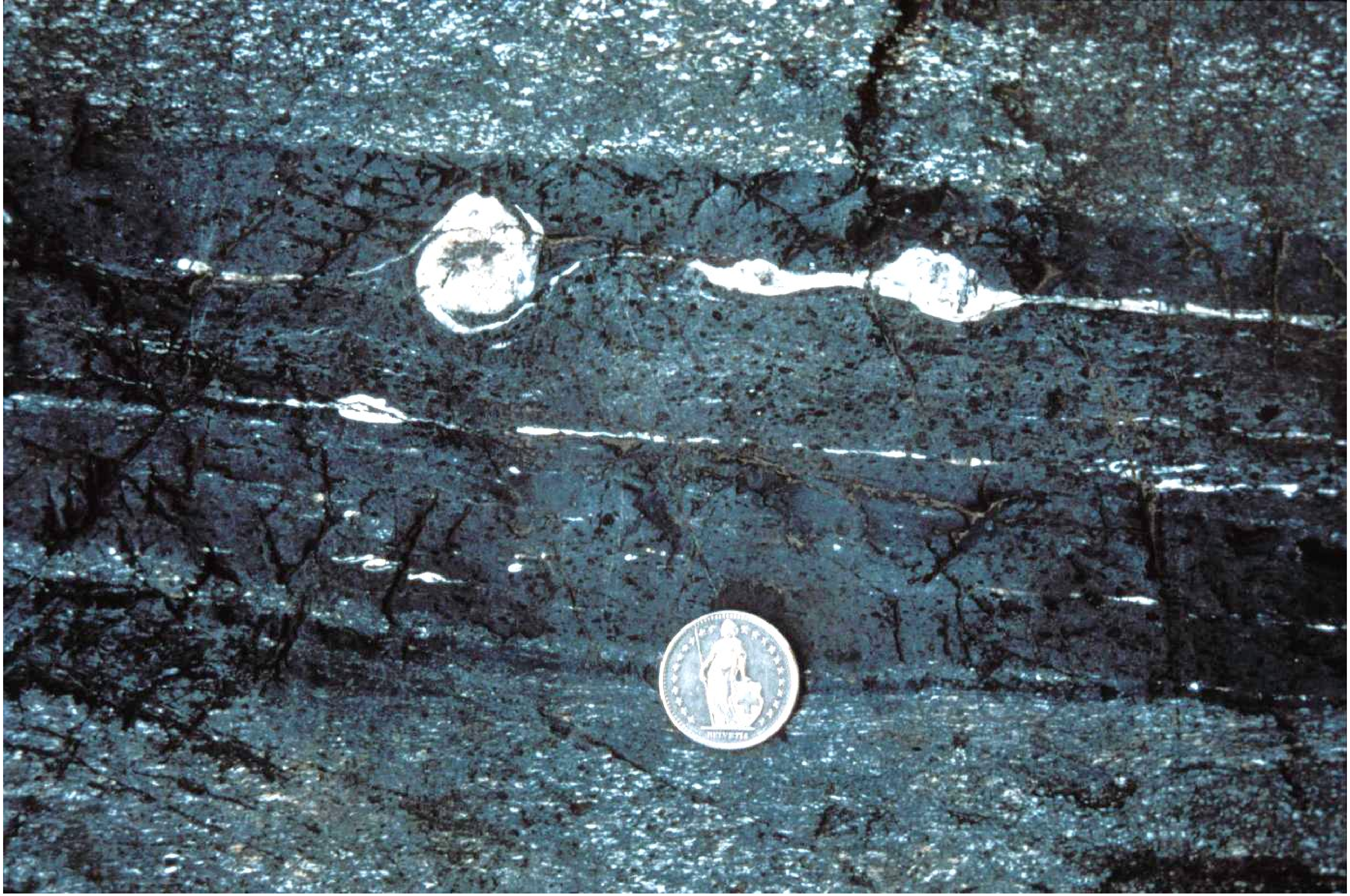
- Secondary structures: (focus of our course)
  - Form in sedimentary or igneous rocks after lithification or in metamorphic rocks during or after their formation
  - Joints and shear fractures
  - Faults
  - Folds
  - Cleavage, foliation, lineation (penetrative)
  - Shear zones
  - Intrusions

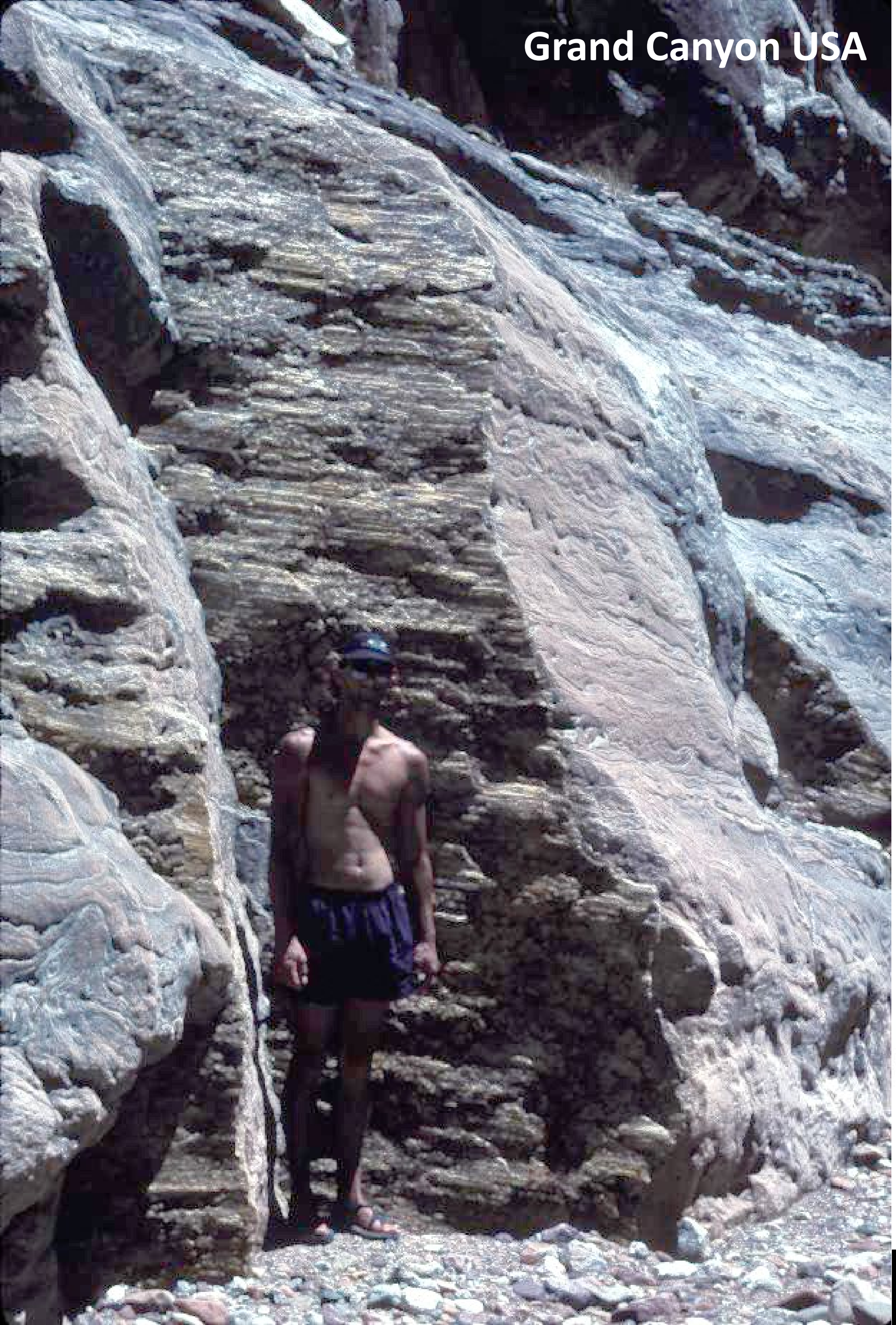



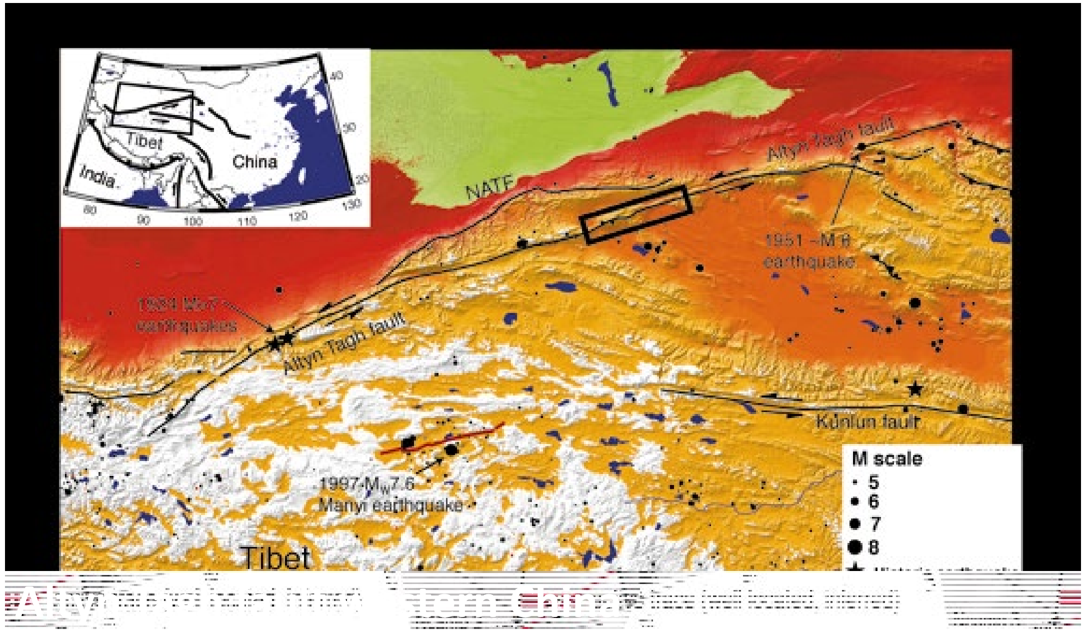



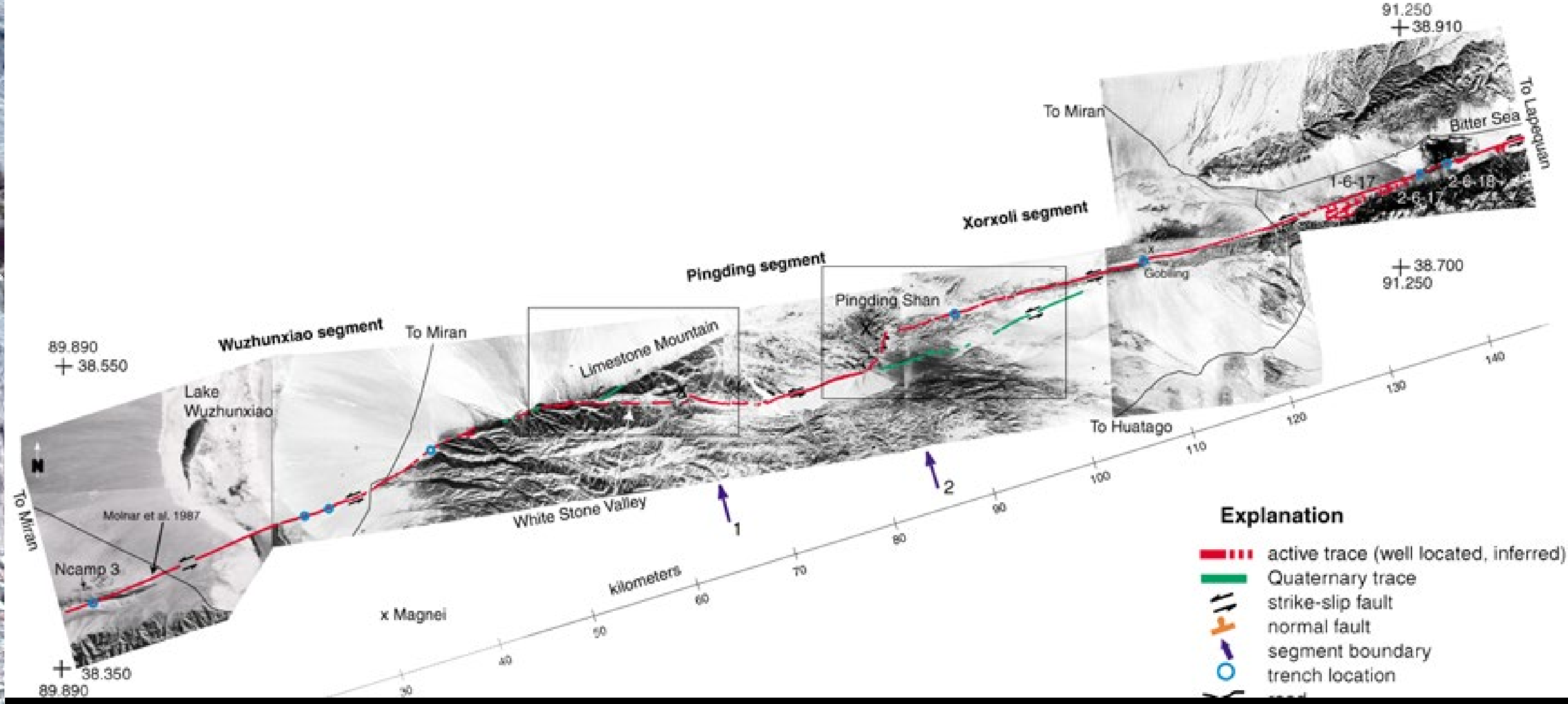

Dallas D. Rhodes, 2004


Burger Structural Geology slide set




Grand Canyon USA


Tibet
China
India
NATF
Altyn Tagh fault
1951 ~M 8 earthquake
1924 Ms7 earthquakes
Altyn Tagh fault
Kunlun fault
1997 Mw7.6 Manyi earthquake
Tibet
M scale
5
6
7
8


91.250
38.910
To Miran
Bitter Sea
To Lapequan
1-6-17
2-6-17
2-6-18
Xorxoli segment
Pingding segment
Wuzhunxiao segment
To Miran
Limestone Mountain
Pingding Shan
Gobiling
38.700
91.250
89.890
38.550
Lake Wuzhunxiao
To Miran
Molnar et al. 1987
Ncamp 3
White Stone Valley
To Huatago
1
2
kilometers
x Magnei
38.350
89.890
Explanation
active trace (well located, inferred)
Quaternary trace
strike-slip fault
normal fault
segment boundary
trench location


Structural Geology slide set

-What are the ultimate questions that a mechanical framework enables us to answer?

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- Why and how do geologic structures form?

- Field Observations + relative or absolute age + uniformitarianism + specify geometry and motions + And apply basic physics

-Why do physically based explanations of structural processes have an advantage over explanations that are not based on physics?

-Why do physically based explanations of structural processes have an advantage over explanations that are not based on physics?

- Physical plausibility
- Idealization for broader application and prediction
- Repeatability

- Easy to talk about, hard to be complete