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Book Reviews

Text-book of structural geology

Hatcher, R. D. 1989. *Structural Geology, Principles, Concepts, and Problems.* Merrill Publishing Co., Columbus, Ohio, U.S.A. 531 pp. Price $49.95 (hardback).

Despite declining numbers of students entering geology programs worldwide, new structural geology text-books continue to appear with increasing frequency. The latest addition is Professor Hatcher's large volume *Structural Geology, Principles, Concepts, and Problems*. This book was designed for the single-semester undergraduate courses offered in most North-American universities. Its stated purpose is "to bridge the gap between older, less quantitative, texts and newer, but more advanced, mathematical structural geology books". The contents are divided into five parts: *Introduction*; *Rock mechanics*; *Fractures and faults*; *Folds and folding*; and *Fabrics, structural analysis, and geophysics*. Many seismic sections, geophysical maps and tables of field data are included. The 28 × 21 cm page format accommodates lots of large, legible line-drawings; however, some of the photographs lack crispness.

The two chapters of Part 1 (*Introduction*) deal with a wide range of topics—geologic principles, tectonics, plate tectonics, geochronology, isostacy, primary sedimentary structures, salt structures, and impact structures. The treatment is generally low-level; for example, students having difficulty with three-dimensional geometry are advised to "begin by attempting to think about familiar objects in three dimensions, such as your car, house or room, then move on to work with less familiar tectonic structures". Flat vision is certainly a problem for some students but one wonders if this advice will help.

Part 2 (*Rock mechanics*) is divided into five chapters: *Stress*; *Strain*; *Measurement of strain in rocks*; *Mechanical behavior of rock materials*; and *Microstructures and deformation mechanisms*. Here becomes evident the book's principal weakness, namely the frequent occurrence of mistakes ranging from typos, such as the interchange of $(\sigma_1 - \sigma_3)/2$ and $(\sigma_1 + \sigma_3)/2$ in the derivation of stress (Fig. 3-9a), to misunderstandings of concepts, as on p. 51: "a *second-rank tensor* consists of vectors and nine components; an example is the northeastward motion of the Gulf Stream at a surface water velocity of 150 cm/s". Space does not permit a full listing of errors, but the most important should be mentioned.

The concept of stress at a point is treated as follows (p. 55ff.): three principal stresses σ_1, σ_2 and σ_3, are considered to act on the faces of a cube; the cube is shrunk to a point and the principal stresses replaced by a single stress σ_0. This stress σ_0 is then resolved into normal and shear stress components on each face of the cube! This treatment guarantees that most students will misunderstand stress for the rest of their careers. Page 61 states that circular sections of the stress ellipsoid define planes of maximum shear stress (this error is repeated for shear strain, p. 72) and in Fig. 4-13 it is suggested that a Mohr envelope be constructed in strain $(\lambda'\gamma')$ space! The errors extend into the special topic boxes (simple shear and pure shear are confused in Fig. 4E-1, for example), the problem sets (e.g. p. 78, "elongation strains $e_1 = 0.6$ and $e_2 = 1.2$"), and the glossary (p. 496, "**LS-tectonite:** Deformed rock wherein linear structures dominate over foliation or cleavage").

Chapter 6 deals with mechanical behavior of rock materials, and again there are confusing errors. A number of graphs are incorrect (e.g. Fig. 6-1d) or mislabelled (stress–strain instead of strain–time in Fig. 6-13b). Page 112 states "From equations (6-1) and (6-6), $\dot{\gamma} = (\tau/G) + (\tau t/\eta)$" but the cited equations are $\sigma \propto \varepsilon$ and $\sigma \propto d\gamma/dt = \dot{\gamma}$. Students will have a hard time deriving the former from the latter. Chapter 7 on *Microstructures and deformation mechanisms* is a considerable improvement with some clear explanations. However the sinistral *S–C* mylonite fabric supposedly illustrated in Fig. 7E-2 is neither sinistral nor an *S–C* mylonite.

Part 3 comprises six chapters: *Joints and shear fractures*; *Fault classification and terminology*; *Fault mechanics*; *Thrust faults*; *Strike-slip faults*; and *Normal faults*. There are many useful diagrams here. However, I found the argument on p. 155 obscure, particularly for students, and the illustration of effective normal stress $(\sigma - P)$ in Fig. 8-13 is incorrect. The reader is referred to Fig. 9-2b for an example of a strike-slip fault, but the figure shows oblique-slip with incorrectly arrowed strike- and dip-slip components and the components of slip and separation in Fig. 9-4 do not seem right. The hanging wall and footwall of the thrust in Fig. 9-11 are incompatible, and the offsets and omission of stratigraphic markers in the block diagrams of Fig. 9-12 are incomprehensible to me. However, I thought most of the fault mechanics material was treated well. Chapter 11 on thrust faults begins with the history of the thick vs thin-skinned thrust controversy. Here, the author is on his own ground and the discussion of Appalachian tectonics is quite high level. There follows an introduction to thrust terminology and mechanics. The real maps and cross-sections are informative, but five of the author's simplified sections are impossible to restore or balance. The following two chapters on strike and normal faulting, respectively, are a little short, in view of the amount of recent interest in these areas.

Part 4 deals with *Fold geometry and classifications, Mechanics of folding* and *Complex folds*. I found some confusion over the definitions of hinge vs crest lines on p. 279, and supratenuous folds in Fig. 14-14 (d). Definitions that ought to be clear and concise are not; "The direction of leaning (the opposite of dip direction) of the axial surface, sense of shear, or the direction of overturning (producing an inverted limb) is called the *vergence* of a fold" (p. 281).

The final part covers *Cleavage and foliations, Linear structures, Structural analysis* and *Geophysical techniques*. Most of the text and illustrations in this section are good. The structural data from Woodall shoals and the geophysical maps and data make particularly good laboratory exercises. Unfortunately, the discussion of balanced cross-sections refers back to Fig. 11-37 where the perplexed student will find, not the promised deformed and restored sections, but rather, the photoelastic effect around a crack tip in Plexiglass! I felt unsure about calling stretched pebbles "natural strain ellipsoids lineation", calling mineral lineations and boudinage sense-of-shear indicators, or calling porphyroblast rotation axes a lineation (pp. 404–405), and I remained unconvinced that the garnet in Fig. 18-7 displays "δ-porphyroblast form". Question 6 (p. 433), "Why is identification of kinematic axes in most areas considered useless or even impossible?" may cause some confused students to reject the important field of kinematic analysis. I couldn't do the last part of question 4.

There are three appendices which deal with *Fabric diagrams, Structural measurements and observations* and *Woodall shoals fabric data*. The procedure for plotting a line (Fig. A1-6) is confusing since its trend is repeatedly referred to as its "strike", and in Fig. A2-2b, the "plunge" of a fold axis appears to be a pitch. In general, descriptions of plotting procedures are insufficient for the uninitiated and superfluous for the experienced student. Lower-hemisphere projection is assumed but not explained.

My general conclusion is one of concern for those students who do not have a diligent advisor to guide them through this text-book's innumerable errors and misunderstandings, a small sampling of which are cited above. Even if they were corrected in a revised printing, a general lack of clarity is pervasive and the emphasis on descriptive classification rather than process is reminiscent of Hills (1963) or Billings (1973). In view of the strong competition from other texts, teachers may find the inclusion of a good geophysics section and good field data insufficient compensation for other shortcomings.

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Rocky Mountains meet the Cordillera

Schmidt, C. J. and Perry, W. J. (editors) 1989. *Interaction of the Rocky Mountain Foreland and the Cordilleran Thrust Belt.* Geological Society of America Memoir 171. Geological Society of America, Boulder, CO, U.S.A. 597 pp with three pocket-plates and one microfiche card. Price $78.