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BOOK REVIEWS

The Swiss Alps: a geological detective story

Hsü, K. J. 1995. *The Geology of Switzerland: An Introduction to Tectonic Facies.* Princeton University Press, NJ, U.S.A. Price (cloth): $55.00, £40.00.

Even now, two hundred years after naturalists began mapping Alpine geology on a large scale, the Alps continue to fascinate specialists and laymen alike. In becoming arguably the best studied mountain belt in the world, the Alps have not only been the breeding ground for basic geologic concepts like sedimentary facies, nappe tectonics and continental subduction (to name only a few), they have acquired prototypical status, serving at times as a model for all collisional orogens.

The development of plate tectonics over the past 35 years has led Alpine specialists to reassess classical Alpine problems in terms of actualistic tectonic processes. This has gone hand in hand with the implementation of modern structural geology, geophysics, petrology and geochronology to reconstruct the kinematic and thermal history of the Alps. Yet with the exception of a few conference guides and pamphlets, there is no book in which these recent developments are really summarized and placed in a historical context. To be sure, such a task is daunting; the Alpine literature is voluminous, ideas are very much in a state of flux, and controversies abound. But despite or perhaps even because of their long history of geologic research, the Alps remain an enigma, incentive enough to engage the wits of a charismatic writer–geologist like Kenneth Hsü.

Ostensibly, Ken Hsü's 'The Geology of Switzerland' is about the geology of the central part of the Alpine chain. But this book is more; it is "a history of inquiry, especially my history of inquiry", as Hsü himself states in the preface to the Swiss edition. Thus, the book is also a discourse on how geology was and is conducted, punctuated by Hsü's anecdotal, sometimes idiosyncratic pronouncements on Alpine geology. This unabashed narrative style lifts Hsü's book above dry, textbook-like recitative, making the book both entertaining to read and some Alpine geological controveries deceptively easy to understand.

The book actually comprises two disparate parts: The first part (Chapters 1–12) is a slightly modified version of the Swiss edition, *Geologie der Schweiz* of Hsü & Briegel, published in 1991, whereas the second part (Chapters 13–16) invokes the old concept of 'Bauplan' or orogenic architecture to interpret the structure not only of the Alps, but of several other mountain chains around the world.

In the first 11 chapters, Hsü adopts a synthetic view of geology, elegantly combining a systematic treatment of the main tectonostratigraphic units in the Swiss Alps with an introduction to classical geological concepts and methods. The development of these concepts is examined in the context of past geologic research in the Alps. So, for example, Chapter 1 on the Jura Mountains not only describes the rocks and structure of the Jura, it also introduces Gressly's (1838) concept of sedimentary facies and discusses Hutton's speculations on Jura folding that eventually lead to the present-day notion of décollement tectonics. Similarly, Chapter 2 on the Swiss Midland is not merely an introduction to the Tertiary and Quaternary rocks of the Molasse Basin, it recounts the nineteenth century debate between de Charpentier, Agassiz and Lyell on the origin of glacial deposits in the Alpine foreland. Chapters on the other tectono-stratigraphic elements of the Alps (the Helvetic nappes, Préalpes, flysch and ophiolite units, Penninic nappes, Austro–Alpine nappes) follow in like manner. In employing this synthetic approach, the author appears to have followed the heuristic method of Rudolph Trümpy, Hsü's retired colleague at ETH who taught the course 'Geologie der Schweiz' to many generations of students in Zürich. Another interesting facet of the text is Hsü's frequent allusion to actualistic tectonic processes that may have contributed to the evolution of the Alps. He documents such processs with striking analogies, such as the similarity of Paleocene Flysch paleogeography in the Alpine–Tethyan realm with current tectonics and sedimentation patterns in the eastern mediterranean. In Chapter 12, Hsü presents a plate tectonic reconstruction of the Alpine orogeny, essentially restating his previously published (1989) idea that the Alps arose from the interaction of three plates during Cretaceous and Tertiary time: the African plate, the European plate, and a third, so-called M or middle plate, which includes present-day Italy.

In the second, newer part of the book (Chapters 13–16), Hsü lays a foundation for classifying and understanding mountain belts on the basis of what he terms 'tectonic facies'. To paraphrase Hsü, tectonic facies is the deformational style of a basement-cover sequence. He specifies two criteria for characterizing this style: the degree to which the basement is involved in a deformation, and the nature (ductile vs brittle) of this deformation. According to Hsü's scheme, therefore, there are three possible tectonic facies: (1) brittely deformed basement, (2) ductiley deformed basement, and (3) undeformed basement whose cover has been detached. Hsü argues that these three tectonic facies are integral to the anatomy of all mountain belts. In a collisional orogen like the Tertiary Alps, for example, the first characterizes the allochthonous orogenic lid (Austro–Alpine nappes), the second facies is found in the underlying basement nappes (Penninic nappes), whereas the third facies typifies basement massifs (External Massifs) whose detached sedimentary cover (Helvetic nappes) has been thrust onto the orogenic forcland. Generalizing from the Tertiary Alpine example, Hsü proceeds in Chapter 14 to identify these three tectonic facies in several other classical orogens: the Southern and Central Andes, the Appalachians and Caledonides, and the North American Cordilleras. In Chapter 15 he analyses the major mountain chains of his native China: the Huanan Alps, the Gunanhai, the Neimonides, and the Tianshan and Kunlun mountains.

For all its demonstration of wit and imagination, Hsü's book suffers from some substantial deficiencies. The first and, in my opinion, most serious of these is the cursory treatment given to the southern Alps. The author justifies this neglect with the argument that most of the southern Alps lie outside of Switzerland, but when during the last fifty years have national boundaries stopped Alpine geologists? Alas, Hsü never mentions the southern Alpine nappes, the Po Basin, the Ivrea granulites or the Ivrea geophysical body, rendering his book an introduction to a transect across only part of the central Alpine orogen. Another shortcoming is that Hsü overlooks some of the main developments in Alpine geology during the decade leading up to 1993, the year signed in the postscript to his book. For example, there is no mention of the complex intercalation of European and Adriatic lower crust and upper mantle beneath the central Alps, one of the most intriguing discoveries of the Swiss Alps deep seismic reflection profiling campaign, NFP–20. This discovery bears significant consequences for the structual evolution of the Alps, as compiled in a joint publication of the Swiss, French and Italian geological societies (Roure *et al.* 1990) and in the monograph of the European Geotraverse (Blundell *et al.* 1992). Similarly, one searches in vain for any reference to the extensive structural and geochronological research conducted in the mid to late 1980's along the Insubric line and the adjacent Penninic, Austro–Alpine and southern Alpine units (e.g. Schmid *et al.* 1989). Finally, the concepts of tectonic facies introduced in the second part of the book promises more than it delivers. This is not really surprising, given the very general nature of the three tectonic facies and the complex structural and metamorphic overprinting reactions in the orogens Hsü examines. After re-reading Chapter 13, I find myself asking whether most tectonists have not advanced beyond Hsü concept of tectonic facies by incorporating metamorphic facies as a criterion complementary to structural style in the analysis of mountain belts. Isn't identifying tectonic facies in mountain belts just another exercise in 'stamp-collecting', to borrow Hsü's favorite quote of Lord Kelvin? To be fair, Hsü states that he has left the full application of the tectonic facies concept to the next generation of geologists. I daren't predict how the tectonic facies concept will evolve in the future. But I think it can only acquire tectonophysical meaning if the spatial distribution of these facies within orogens can be related to their plate tectonic setting and evolution. Herein lies Hsü's challenge to the next

generation and the starting point for his plea in Chapter 16 ('Theoretical geology'): for professional tolerance in the evaluation of new, sometimes undocumented ideas.

While I can certainly recommend *The Geology of Switzerland* to all *Journal* readers, I do so with some reservation. The book is engaging, mostly because it reads like a detective story; controversies in Alpine geology find their resolution in the development of new methods or the conceptualization of new geological processes, which in turn inspire the next generation of geologists. This is the stuff of which science is made and in this regard, the book cannot fail to capture the minds of interested readers. However, in neglecting important elements of the Alpine orogen and in failing to update the older Swiss edition of his book, Hsü has missed a golden opportunity to pass on a balanced, state-of-the-art document to serious students of Alpine geology. Both points are important to consider when using the book as an introductory text.

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Central American island arc

Seyfried, H. and Hellman, W. (editors) 1994. *Geology of an Evolving Island Arc. The Isthmus of Southern Nicaragua, Costa Rica and Western Panama. Profil* (Band 7), Institut fur Geologie und Palaontologie Universitat Stuttgart, Germany. 433 pp. ISSN 0941-0414.

This dedicated volume of the journal *Profil* of the University of Stuttgart contains 22 short to long papers on Central America and the nearby Atlantic and Caribbean. Topics concentrate on igneous petrology and petrogeny, sedimentation and stratigraphy, paleontology and paleoclimates, and paleogeography. Fifteen papers discuss various aspects of Costa Rican geology, including five on the pre-Campanian Nicoya Complex (generally considered an ophiolite). There are six other papers covering other parts of Central America, and one on Colombia and southern Panama. One paper by Montero discusses stress distributions derived from neotectonics, but otherwise there is no detailed structural geology in the volume. Several of the articles deal with the plate tectonic framework of Central America and the Caribbean in the Mesozoic and early Tertiary. Two papers (Krawinkel & Kolb, Obando *et al.*) describe sedimentary deposits related to strike-slip faulting such as pull-apart basins, and Bottazzi *et al.* give profiles of listric thrusts. Several papers, especially that by von Heune & Fluh, discuss the indenting affect of the Cocos Ridge and the buttress effect of the Nicoya Complex, on subduction in the Middle American Trench.

There are 31 different authors from 18 institutions: European (11), North American (2), South American (2) and Costa Rican (3). The bulk of the Europeans are German. Seventeen papers are in English, 4 in Spanish and 1 in German.

The first three papers (Winsemann, Donnelly, Krawinkel & Seyfried) discuss paleogeography and plate tectonic aspects of the Caribbean Plate and especially its southwestern edge in Central America. The next three papers (Appel *et al.*, Meschede & Frisch, Tournon) give geochemical and geochronological details. The next four papers (Kussmal *et al.*, Montero, von Heune & Fluh and Barboza & Zucchi) discuss igneous rocks, neotectonics, offshore geophysical studies and seismic stratigraphy. Four more papers (Astorga, Calvo & Bolz, Gursky and Winsemann) cover the Nicoya Complex (Cretaceous basalt, peridotite and associated sediments) and suggest several origins. Four papers (Seyfried *et al.*, Krawinkel & Kolb, Obando *et al.* and Bottazzi *et al.*) describe details of the Neogene sedimentary basins, and three papers (Fischer & Aguilar, Lucas & Alvarado and Hooghiemstra) cover land vertebrates, palynological data and other paleontological details. The final paper by Sprechmann *et al.* presents a stratigraphic chart of Costa Rican sedimentary basins.

This book does a good job of covering the geology of Central America, although most of the details are from Costa Rica, Nicaragua and northern Panama. It is a valuable book for those interested in ophiolites, igneous geochemistry, Central American stratigraphy and small tectonic plates. It has good background data on other aspects of Central American geology and paleontology, including several papers describing offshore sedimentary profiles. The several reference lists will be valuable to new workers in Caribbean geology. It is well put together by the editors, has a minimum of minor misprints, and seems fairly sturdy (it survived my reading without falling apart).

Flushing, NY, U.S.A. *Peter H. Mattson*

Plugging a physical gap

Chapman, R. E. 1994. *Physics for Geologists*. UCL Press, London. Price: £35.00 hardback; £12.95 paperback.

This modest book, in price and size, brings together the principles and mathematics of physics which are relevant to geology. Written for students or professional geologists who have forgotten the physics learnt at school, or for those who have gaps in their physics education, this 143-page book sets out basic principles and processes of physics which are needed by geologists, in a clear and simple fashion. The writing is straightforward, and the subdivisions of the book make it easy to use as a reference text. I have reviewed the book as a structural geologist, not as an expert physicist or geophysicist.

The book begins with 'Basic concepts: dimensions, definitions and dimensional analysis' (Chapter 1). All are nicely presented, with the latter put into the context of geological modelling. Chapter 2, entitled 'Force', deals with statics and dynamics, inertia, energy, equilibrium and gravity. A short third chapter on 'Optics' then deals with reflection and refraction, and briefly defines polarization, pleochroism, birefringence and stereoscopy. These might have benefited from more illustration, rather than relying mainly on text. The physics becomes more compressed in Chapter 4, 'Atomic structure': just 4 pages of definitions of neutrons, protons, electrons, α and β particles and isotopes. Chapter 5 follows on with 'Electromagnetic radiation', presenting the physics of radiation, isotopes and age dating. These two chapters might well have been combined.

Short chapters on 'Heat flow' (6) and 'Electricity and magnetism' (7) provide important physics for geological and global processes, but might usefully have focused on important geophysical applications. For example, I searched for the information on magnetic reversals, so important in the development of the ideas of sea-floor spreading. Just a sentence at the end of the chapter mentions palaeomagnetism, and yet this is probably one of the most important applications of physics to geology, which underpins polar wandering, sea-floor spreading, and thus the whole of plate tectonics.

A structural geology audience such as this *Journal's* might be particular interested in Chapter 8 'Stress and strain'. It begins with a good summary of force and stress, but strain is defined only briefly as 'the change of shape or volume of a body as a result of stress'. The definition, $\varepsilon = \delta l/l$ comes later, in the section on elasticity and Hooke's Law. Next comes friction. Viscosity is considered here, defined as the property of internal friction of a fluid. Sliding is considered next, then just half a page on bending and folding, with no mathematics or physics, and no mention of the Biot–Ramberg approach. The chapter goes on to consider fracture, in terms of Coulomb criteria and the Mohr circle, and ends with compaction and consolidation. 'Stress and strain' thus includes quite a mixture of physical processes and models of material behaviour, yet 'rheology' and 'plasticity' are not introduced nor defined.

Chapters 9 and 10 are, respectively, 'Sea waves and acoustics' and 'Sound and other waves'. Given the breadth of topics in the previous chapter, these related topics might more sensibly have been combined.