Principles would suffice as a text in a seminar course for upper level undergraduates and graduate students, provided additional resources were available to examine some topics in greater depth. This book might also find an audience with in-service professionals who wish to get a review or overview on rock mechanics. For geotechnical applications, however, a good engineering geology text would nicely complement *Principles*. Of course, dedicated students may get out their hand lenses and read Elasticity, Fracture, and Flow by Jaeger (1969, Chapman Hall), or C. Jaeger's Rock Mechanics and Engineering (1979, Cambridge University Press).

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The Manson Impact Structure, Iowa: Anatomy of an Impact Crater

Koeberl, Christian and Anderson, Raymond R. (eds) The Geological Society of America Special Paper 302, 476 pp., $99.50. ISBN 0-8137-2302-7.

A 2 km diameter meteorite travelling at 20 km/s, northwest across northern USA, hit the Earth at a low angle of perhaps 30 in Iowa, near the town of Manson. The impact caused a crater 38 km in diameter, yet the oblique angle of the impact meant that it was only 325 m deep and threw debris in a mainly northwesterly direction, as far as 500 km away into Nebraska and South Dakota. Early reports tell of a tsunami covering Sioux City in several metres of sediment and causing major disruption to the Missouri River.

Now ask yourself why you haven't heard about this disaster.

Well, OK, it happened 74 million years ago so you didn't miss it in the TV news... but the real reason is that it didn't kill many dinosaurs or cause any mass extinctions as far as we know. Meteorite impact craters are not rare, they are actually fairly common: with over 20 in the U.S.A. alone and over 150 on Earth, the historical problem has been the 'humour' factor. Until the Alvarez *et al*. paper in *Science* in 1980 made people take notice of the subject, very few were brave enough to risk their research careers on something which might cause amusement and derision among their colleagues. In fact although you may not have heard of the Manson crater, it is now one of the best understood and intensively studied craters on Earth and as such has a great deal to teach us about the mechanisms of crater formation. Before the discovery of the Chicxulub crater on the Yucatan peninsula, Manson was one of several suspects for the K/T mass extinction.

The Manson Impact Structure, Iowa, Anatomy of an Impact Crater is a collection of articles which arose from work on core samples after the Iowa Geological Survey Bureau and the US Geological Survey drilled the Manson Crater in 1991–1992. Just about every conceivable microscopical, chemical, isotopic, and geophysical technique was thrown at these core samples. The result is a unique and fairly exhaustive series of studies into all aspects of terrestrial crater formation showing what can be uncovered concerning crater formation processes from geology. In fact the work covers everything from simple petrography and documentation of the lithologies, to detailed trace element geochemistry of the impact rocks and their products, isotopic dating, microstructural studies, and even tracing the ejecta caused by the impact into possible tsunami deposits in neighbouring geological formations. In such a collection some of the work is bound to be slightly obscure and the various detailed geochemical studies seem now fairly redundant, not adding anything to our knowledge of the impact. However, in all fairness, they must be seen in the light of the original motivation for the work. Why did they drill this particular crater? The reason is that it was known from stratigraphical constraints to have formed around the time of the K/T boundary. Couple this with the fact that it's in America where most of the best preserved K/T boundary samples have been found and the fact that two years earlier a paper published in *Science* indicated an age of 65 Ma, coinciding exactly with the boundary. When the studies were initiated, the workers thought they were dealing with a crater which may have thrown debris around the world. Understandably, workers were attempting to document the geochemistry precisely in order to compare them with ejecta found across the continent. When, a few years later, the age was revised to 74 Ma, the detailed geochemical studies became much less meaningful but they have been included because this is the only place where such studies could be published.

From a structural geology point of view, the book has one big plus and one big minus; it lacks a good study of the macroscopic deformation features, yet it contains several papers describing and illustrating microstructures, particularly the famous PDFs (planar deformation features). Although detailed seismics were shot, there seems to have been no attempt to look for listric faults of a collapsing crater wall as seen in the Sudbury Impact and there appears to be no analysis of shear indicators in deformed samples within the country rocks. On the other hand, the analysis and descriptions of PDFs (regarded by many as the most reliable indicator of a meteorite impact) are excellent. In fact this is the best series of papers detailing these critically important features I have seen collected together and treated in context with their source.

There are also good papers on the Ar–Ar analysis of shocked, mixed feldspar (K-feldspar and plagioclase), analysis of the hydrothermal alteration which seems to be a characteristic of all impacts and both theoretical and experimental consideration of the asymmetry of the Manson Impact. Finally there is a wonderful pair of papers, worth reading even without the rest of the book; the first by Maureen Steiner and Gene Shoemaker putting forward the case for an extensive deposit northwest of the Manson impact crater as a tsunami deposit and the second by Brian Witzke, Richard Hammond and Raymond Anderson describing the same deposits and coming to completely different conclusions. It is of course impossible to know who is correct without further work but the two papers are a great example of two groups looking at the same rocks, through different eyes.

Whether you buy this book or not, I heartily recommend it as a source book for meteorite impact studies.

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